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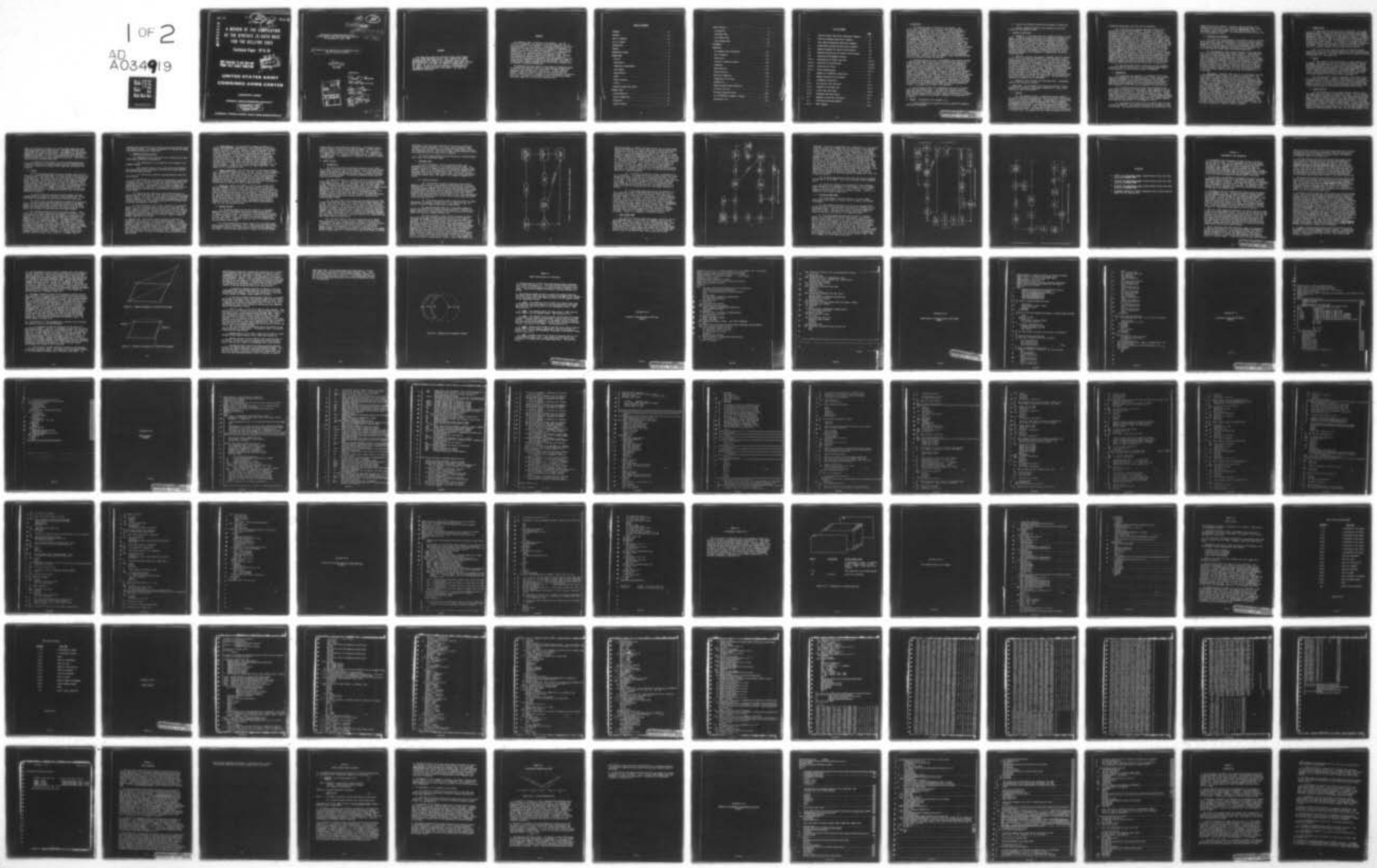

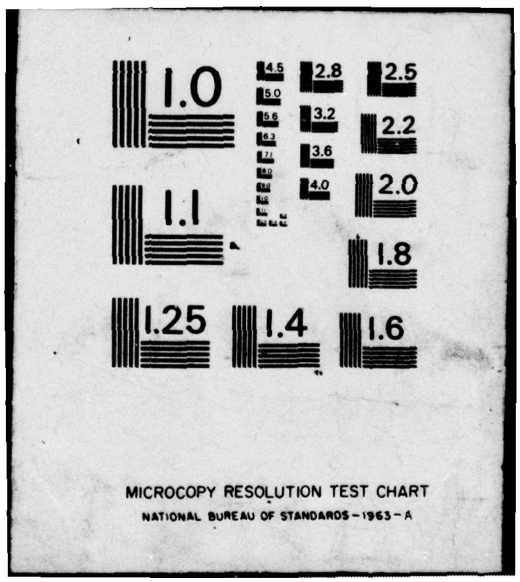
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A REVIEW OF THE COMPILATION OF THE DYNTACS (X) DATA BASE FOR THE HELLFIRE COEA

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6 A Review of the Compilation of the DYNTACS(X) Data Base for the Hellfire COEA

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FOREWORD

This report was prepared by direction of Chief, Model Support Division, Combat Operations Analysis (COA), Combined Arms Combat Developments Activity (CACDA), Fort Leavenworth, Kansas under the Hellfire COEA ACN. The report was prepared for Model Support Division, COA, CACDA. Mr. Ross A. Wells, Mr. Herbert O. Westmoreland, and Mr. James F. Fox assisted in the preparation and documentation of the computer programs included in this report. This report was completed on 3 June 1976.

ABSTRACT

The DYNTACS(X) model is difficult to use properly. Its size (1.25 to 1.5 megabytes) and complexity (over 300 subroutines) are the main contributors to this situation. A thorough knowledge of the entire program and data base, and the interaction of these two components, is required for a professional application of DYNTACS(X). One of the most demanding aspects of the operation of DYNTACS(X) is the preparation of the data base. An improperly prepared data base will impair the credibility of any results produced by the DYNTACS(X) model. Although the documentation prepared by Ohio State University is generally sufficient for the purpose of determining data requirements, it does not always provide a method for producing the required data. This report includes several computer programs and data preprocessor programs, which are valuable in producing required data.

The DYNTACS(X) data base contains a large amount of subjective inputs. In some cases the subjective inputs are required because an empirical data base is not available (e.g., suppression). In other cases the subjective inputs are required to play tactical decision rules and tactics. Experience can be a valuable aid in the preparation of subjective input data. This report is an attempt to codify the experience gained during the preparation of the HELLFIRE COEA data base.

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1. INTRODUCTION.

a. The DYNTACS(X) model is difficult to use properly. Its size (1.25 to 1.5 megabytes) and complexity (over 300 subroutines) are the main contributors to this situation. A thorough knowledge of the entire program and data base, and interaction of these two components, is required for a professional application of DYNTACS(X). One of the most demanding aspects of the operation of DYNTACS(X) is the preparation of the data base. The persons collecting the data serve as intermediaries between the model and the military and scientific communities. They must understand the programming in sufficient detail to explain the applications and implications of each data element. They must be able to translate model assumptions and internal workings into military terms so that tactical input can be quantified by military personnel who are not familiar with the model. They must be able to define the requirements for technical data needed to represent all the weapons sytems depicted and insure that the method of data production does not contain any assumptions or procedures that are incompatible with the DYNTACS(X) use of the data. Because of these requirements, highly qualified personnel should be assigned to prepare the data base.

b. Different agencies that have used DYNTACS(X) have produced programs to make the preparation of portions of the DYNTACS(X) data base easier or more accurate. (The original authors of most of these programs are unknown, so no effort has been made to credit programs to individuals.) Those analysts who have prepared a data base have developed experience and insight into this preparation process. To the present time these programs and insights have not been collected or codified in any systematic manner. This document is an attempt to formalize the experience gained through the preparation of the data base for the HELLFIRE and Cannon Launched Guided Projectile (CLGP) COEAs. Because of its orientation this document does not replace the DYNTACS(X) documentation written by Ohio State University; rather, it serves as a supplement to the documentation by explaining how some of the data elements can be generated. (Some modifications made to the model during the HELLFIRE/CLGP COEAs do modify the documentation slightly. The changes are included in this document.)

c. As an auxiliary effect, this documentation can serve to acquaint users with the DYNTACS(X) model. The body of this document contains a brief description of the model to familiarize the reader with the overall model structure before the detailed model process documentation is presented. In the initial reading of this document, references to the appendixes can be ignored.

2. PURPOSE. The purpose of this document is to:

a. Provide insights and assistance for analysts detailed to prepare a data base for DYNTACS(X).

b. Preserve the DYNTACS(X) preprocessing programs for future use.

c. Provide a vehicle for familiarizing analysts with the basic structure of the DYNTACS(X) model.

3. OVERVIEW OF DYNTACS(X).

a. DYNTACS(X) is a two-sided, small unit computer simulation of land combat. It employs dynamic route selection for attacking elements and makes extensive use of random processes to determine the outcome of a particular event. DYNTACS(X) uses individual vehicles, crew-served weapons, and helicopters as basic elements. The model can be used to represent a variety of weapons: tanks; antitank guided missiles; air defense missiles and guns; indirect fire including artillery of various calibers, mortars, multiple rocket launchers, and guided artillery projectiles; minefields, hand emplaced or delivered by artillery or air; helicopters operating in the autonomous or remoted modes; and ground indirect HELLFIRE.

b. DYNTACS(X) represents each weapon's firepower, mobility, vulnerability to fire, and detection capability and the interaction of these characteristics with the terrain. The terrain is described in terms of ground configuration; surface roughness; soil type; and location, height, and density of vegetation. This detailed description of each weapon and the terrain allows the portrayal of the interaction between the weapon system's characteristics and the terrain. Moreover, the effect of changes in tactics, organization, firing doctrine, and vehicle characteristics on this interaction can be examined. Although there is no arbitrary limit on the number of vehicles used or the number of different types of vehicles played, core storage and running time constraints make simulation of battles above battalion size impractical. COP and FEBA forces (defending or delaying) can be represented.

c. DYNTACS(X) can be divided into three major areas: ground game, indirect fire, and aerial vehicles.

4. GROUND GAME. The ground game can be further divided into terrain, organization, formations, intelligence, communication, routes, target selection, firing, and minefields.

a. <u>Terrain.</u>

(1) The DYNTACS(X) terrain is composed of two main features: the ground configuration (macroterrain) and the description of the characteristics of the ground (microterrain). The macroterrain is derived from elevation data provided by Defense Mapping Agency (DMA) or Waterways Experimentation Station (WES). An imaginary grid is superimposed over the DYNTACS(X) battlefield. The size of the battlefield and the spacing of the grid can be varied. A 5km x 10km battlefield and a 100-meter grid spacing are typical. The elevation at each of the grid intersections is stored as data. The computer can then interpolate between grid points

to determine the height at any point on the battlefield.

(2) A description more complete than that provided by the macroterrain is required for DYNTACS(X). Therefore, a series of descriptive overlays is added to the macroterrain. These overlays are formed by placing circles and parallelograms on the terrain. The placement of these geometric figures is controlled by a detailed analysis of the terrain performed by WES but is independent of the elevation grid. The WES analysis identifies the location of different soil types, vegetation, and other land characteristics. When prepared (see appendix A) the series of overlays will describe the following characteristics of the land: soil type, which will interact with the macroterrain (slope) and mobility characteristics of the different vehicles to affect the speed of each vehicle; vegetation (includes density, height, and widths of individual pieces of vegetation), which will interact with the macroterrain and vehicle heights to affect line of sight, the percent of a vehicle exposed for detection, and the capability of vehicles to move undetected; surface roughness, which will interact with vehicle mobility characteristics to impose a maximum speed that can be attained by any vehicle; cover (see appendix B), which will interact with vehicle height to determine the amount of a vehicle exposed to the effects of enemy fire and the probability of achieving hull defilade when moving into a firing position.

(3) The detailed description of the terrain and its extensive interaction with the characteristics of the individual combat elements provide the basis for the interactive nature of DYNTACS(X).

b. Organization.

(1) Organization (see appendix C) in DYNTACS(X) has its major impact on the movement of the respective forces. Hence, organization is relatively unimportant for a static defensive force, but of great importance to a mobile attacking force. Therefore, a static defensive force can be simply organized into the COP force and the FEBA force. After withdrawal, the COP force can be integrated into the FEBA force.

(2) A tactically realistic portrayal can be achieved if the threat force is organized on a platoon basis. When organized in this way the platoons will act as units. The platoon leader determines the route to be taken, the formation to be used, and the speed of travel. Platoon members merely guide on the platoon leader. If a platoon member detonates a mine, the platoon as a group takes action to counter the minefield threat. If the attackers are organized on a company basis, the company commander would make the same decisions for the company as a whole.

(3) The defending force does not use the dynamic route selection routines in DYNTACS(X). The rationale upon which this procedure is based is as follows: The defending force will withdraw over terrain that it has

"owned" and had time to explore. Therefore, when the defending force withdraws, as from the COP, it will move over preselected routes. Since the routes will have been selected for their characteristics (cover, concealment, speed of withdrawal), the withdrawing force does not vary from the routes provided as input.

c. Formations and Deployment.

(1) Essentially, the deployment of the defending force is specified by the input data. Each defending weapon is placed on a specific spot on the ground (see appendix D). In addition to the location of each defending weapon, it's cover (how deep it is dug in) and concealment (how close it is to the nearest clump of vegetation) characteristics are specified. The cover value does not change unless the defending weapon moves.

(2) The deployment of the attacking platoons is more complicated since it is controlled by the actual combat situation. As the attacking force starts to detect enemy weapons it will modify its maneuver unit formations as a result of these detections (see appendix E). The maneuver units are presently allowed by input data to select a column, line, echelon right, or echelon left formation. Each of these formations has a desired speed associated with it. Thus, units moving in column will attempt to maintain a relatively high speed reflecting the ease of control and rapid movement afforded by this formation. When other formations are adopted, the desired speed is reduced in order to reflect the increased difficulty in controlling these formations and allow a more rapid deceleration to firing speed.

d. Intelligence. DYNTACS(X) keeps track of the intelligence available to each individual combat element on an element by element basis. The intelligence will generally consist of three different levels: no knowledge, general knowledge (subject element was previously detected or the subject of an intelligence message), or full detection (sufficien knowledge to engage). At the beginning of each event the subject element will have its intelligence updated. If the current element has lost line of sight with a detected element, its intelligence about that element will be reduced to general knowledge. If it has established or maintained line of sight with any element, it will be given an opportunity to make a detection. The probability of detecting any element is computed dynamically based on the range between the two elements, the optics used by the observer, the amount of the observed vehicle that is exposed, and the length of time available to the observer. Having general knowledge of an element significantly increases the probability of detecting that element. Once an element makes a detection, it keeps that level of knowledge until line of sight is broken or the detecting element is suppressed. In either case the level of knowledge is lowered to general knowledge.

e. Communications.

(1) Radio nets are played explicitly in DYNTACS(X). Each combat element is placed on one or more radio nets representing platoon, company, and battalion nets. Elements use the radio nets to transmit intelligence messages and tactical information to other elements on the net. Information received by a leader on a lower net is automatically relayed on the higher level net and vice versa. When an element uses a net, it prohibits the use of that net by another element. If an element has a message to send and finds the net busy, it must wait until the net is clear before transmitting its message. If more than one element is waiting to use the net, the next user is randomly selected from those waiting to use the net.

(2) The US nets are organized according to standard procedure: tank platoon on one net, each infantry platoon on one net, and each platoon leader on the company net. The threat radio net must be organized according to threat doctrine. (See appendix C).

f. Routes.

(1) Each platoon in the attacking force is given a general route of advance. Each platoon guides on this route as it advances. However, the platoon may deviate from its route to take maximum advantage of the terrain and vegetation, avoid exposing itself to detected enemy weapons, and avoid traversing known minefields. This dynamic generation of routes is one of the outstanding features of the DYNTACS(X) model. The optimal route is recomputed whenever there has been a sufficient change in the intelligence available to the platoon leader (see appendix F).

(2) The importance of cover or concealment versus fields of fire will vary during the battle. Initially, each maneuver unit will attempt to make maximum use of the concealment or cover provided by vegetation and land form. It will also seek to avoid exposing itself to detected enemy weapons. However, as the attacking force approaches within assault range of the FEBA the routes are then selected to maximize fields of fire.

g. Target Selection.

(1) During each event for an element the model checks to see if the element being considered has detected any targets. If it has detected any enemy elements, the model determines if those enemy elements are within range. If there are enemy elements within range, the model evaluates each detected element within range based on seven characteristics: the range to the target, whether the potential target was just fired on by the selecting weapon, is engaged by another friendly element, is within the selecting weapon's sector of fire, is firing, is firing at the selecting weapon, and the type of weapon the potential target is. Here the model assumes that an element can differentiate among tanks, APCs, and crew-served weapons. How-

ever, it is not given the capability to differentiate between non-radar directed AD weapons and infantry carriers. AD weapons with radar discs are assumed to be uniquely identifiable. (See appendix G.) The potential target with the highest priority based on these seven characteristics is selected as the target. A round is then selected for the firing event based on availability and a set of ammunition priorities. These priorities vary with actual range and target type.

(2) Because of their unique role the air defense weapons use a different set of values to establish target priority. These priorities allow an air defense gun to engage ground targets when aircraft are not available.

h. <u>Firing</u>.

(1) If the engaging element is moving, the model checks to see if the speed is above the allowed speed for firing on the move for that vehicle. If the vehicle is traveling too fast, the model requires it to slow down to the allowed speed. The attacking tanks will fire two rounds at a selected target. The first round will be fired as soon as the element reaches its fire-on-the-move speed, the second will be fired at a short halt. After firing two rounds, the engaging element will then cycle through the target selection procedure while it resumes it's advance. Because of their relatively slow rate of fire, SAGGER carrying weapons will fire only one round before reevaluation. The defensive force will also fire one round between prioritization.

(2) While controlling the speed of moving elements, the model randomly selects a load and lay time from an input distribution. It uses the maximum of these numbers to determine when firing can take place.

(3) After firing, the model computes the probability of achieving a hit. In this calculation the following major factors are considered: whether the firer and/or target is moving, the aim error for the firing weapon, the round-to-round dispersion for that round fired by the firing weapon, and the degree of cover available to the target element.

(4) A firing initially can have one of three outcomes: a miss; a near miss, which causes suppression (see appendix H), or a hit. If the firing results in either of the first two outcomes, no further action is required. If a hit is achieved, then the damage must be assessed. The damage may fall into four major categories: no damage, maneuver only, firepower only, or firepower and maneuver. (See appendix I.) The probability of each type of kill is read from an input table and will vary as a function of round type, firer type, target type, range, speed of target, and aspect angle between firer and target. If the hit results in no damage, the vehicle is suppressed for a period of from 5 to 10 seconds (input values) depending on the type of vehicle. If a maneuver only kill is assessed, the target vehicle is suppressed for 2 minutes (input value) and then allowed to resume firing. Similarly, a firepower only kill

suppresses the target vehicle for 2 minutes (input value) and then allows it to continue moving. A firepower and maneuver kill removes the element from further participation in the battle.

i. Minefield Countering Tactics.

(1) DYNTACS(X) requires the threat force to employ one of three tactics when a minefield is encountered:

(a) Retrograde out of the minefield, move laterally, and attempt to bypass.

(b) Use mine plows to clear a path through the minefield. When using the mine plow, the maneuver unit must use a column formation with the plow vehicle leading.

(c) Traverse the minefield, accepting whatever casualties are inflicted.

(2) The decision as to the tactic to be employed in a particular instance is based on the range from the FEBA. Beyond 3,000 meters; that is, outside of ground direct fire range, the tactic of choice is the retrograde and bypass. Each maneuver unit is allowed to employ this tactic only once. This restriction is enforced to avoid repetitious use of this tactic when encountering a single minefield, resulting in a "yo-yo" effect.

(3) Between 500 and 3,000 meters from the FEBA the tactic of choice is the use of the mine plow. Each platoon has one vehicle equipped with this device. This tactic is used as often as necessary in the range interval; dependent, of course, on the specially equipped tank's survival. The use of the mine plow is predicated on the desire of the threat force to maintain the momentum of the attack.

(4) Once the maneuver unit is within 500 meters of the FEBA the threat force enters the assault phase of the attack. Once within the assault range it is essential that the attackers close with the defensive force as rapidly as possible. Because of this desire to close as rapidly as possible, the threat force will adopt the third tactic in this range interval and traverse the minefield in a tactical formation, accepting whatever casualties are inflicted.

5. INDIRECT FIRE. The artillery support available to each side is determined by tacticians prior to the data base preparation. In some instances it may be desirable to allocate only a portion of an artillery battery's support to a particular unit (e.g., a US company in the defense will receive only a fractional battery for artillery support). In these cases, DYNTACS(X) provides for a false FO to generate imaginary missions to tie up a portion of the artillery battery's time. (See appendix J.) Each artillery battery is placed on the ground with the location of each tube recorded.

a. Forward Observer. The FO function is normally assigned to a vehicle as an additional responsibility. The FO function is interrupted whenever the vehicle is firing. Therefore, it may be desirable to provide a vehicle that has no ammunition to be the original FO vehicle. This is especially true when the FO party is provided with special equipment such as a laser designator. If the element carrying the FO is killed, the responsibility for the FO mission is normally passed to another element in the same maneuver unit. When all elements in the FO's maneuver unit are dead, the FO function lapses. An exception to the transfer of the FO responsibility exists when the FO party carries special equipment (e.g., laser designator). In this case, if the FO vehicle is destroyed (i.e., the special equipment is damaged), the FO function lapses immediately. (See appendix K for a discussion of CLGP.)

b. Types of Ammunition. Blue artillery can fire three types of ammunition: conventional, scatterable mines, and CLGP. Because of the programming used in the artillery model, CLGP rounds are fired to the exclusion of all other types whenever CLGP rounds are available. When mine and conventional rounds are both available, the mine rounds are the preferred ammunition. Conventional rounds are fired only after the mine rounds have slowed the attackers to plow speed. (See appendix L for a discussion of fire planning.) Red artillery is restricted to using one ammunition type.

c. Processing. When an FO attempts to call for fire, he must first have a fire request net that is free. Once that condition is satisfied, the model assesses a series of time delays until fire is actually delivered. Each delay represents one step of the fire request processing procedure. All delays are random selections from time distributions. The delays correspond to: the time required to transmit to fire request message; the time required for the FDC to process the request; the time required to send the firing data for the processed request to the battery; and the time for the loading, laying, and firing of the initial volley. Subsequent volleys follow at intervals prescribed by successive realizations from the distribution to load, lay, and fire subsequent volleys.

d. Terminal Effects.

(1) The expected impact point of each projectile is calculated based on each tube's displacement from battery center and the desired aim point. The center of mass of these points is calculated and an ellipse is oriented around this point. The dimensions of this ellipse are specified by input. Any elements inside this ellipse are considered suppressed by this artillery volley. Suppression times are from 5 to 10 seconds (input) and vary based on vehicle type.

(2) After determining the expected impact point, the actual impact point for each round is determined. This is done by sampling from the range and dispersion probable error distribution and offsetting the projectiles accordingly. Once the actual impact point is known, a circle with 50-meter

(input) radius is drawn around each impact point. Any element inside a circle is subject to suppression and possibly damage. Probabilities for each kill type are stored in tables based on vehicle type. The actual kill type produced is based on a random number draw. If a maneuver only or firepower only kill is assessed, the damaged vehicle is suppressed for 2 minutes (input). If a complete kill is assessed, the vehicle is removed from the battle.

6. AERIAL VEHICLES.

a. Introduction.

(1) Each aerial vehicle constitutes a maneuver unit by itself. This is done so that each vehicle can calculate its own flight path without regard to the location of other aerial vehicles. This allows each aerial vehicle to optimize its withdrawal route and, hence, minimize its vulnerability to air defense weapons. The present programming assumes that only Blue will use helicopters.

(2) Each aerial vehicle is provided a series of up to five operational areas to work in. The only tactic allowed by the present programming is the "popup and hover" method of engagement. Three operational modes can be used: autonomous attack helicopter, ground remote, or scout remote designator. The last two modes are applicable only to laser directed missiles. Each operations area has a maximum altitude associated with it. (See appendix M.) When an aerial vehicle rises to its maximum altitude, it is at least 15 meters (input) above near mask for that operations area. Therefore, the aerial vehicle will be able to observe a significant portion of the battlefield without unduly exposing itself to observation and attack by enemy elements.

(3) The aerial vehicles are brought onto the battlefield and flown to their first operations area a short time before the ground elements start to move. Hence, all helicopters are in place, ready to detect and attack when the battle begins. As the threat force launches its attack and closes the distance between itself and the aerial vehicles, the aerial vehicles will withdraw to successive operations areas in order to maintain the specified standoff range. When an aerial vehicle withdraws to a subsequent operations area, it selects the optimal route in the same way that the ground elements do. While executing a withdrawal, the aerial vehicles fly a nap-of-the-earth path 5 meters above the macroterrain.

(4) The aerial vehicles utilize two countermeasures to reduce their vulnerability to air defense weapons. Whenever an aerial vehicle is exposed for the purpose of detecting threat elements or guiding a missile to its target, the aerial vehicle performs a series of random evasive motions to avoid the presentation of a stationary target for the air defense elements. The second countermeasure is the employment of the AN/APR-39 with a range capability. An aerial vehicle acquired by threat air defense

radar that is within the range specified will be given the opportunity to remask to avoid engagement. If an aerial vehicle receives a radar warning, it will abort its mission and attempt to remask unless a missile has already been launched. After missile launch, the guiding aerial vehicle will guide the missile to impact prior to remasking.

(5) The following sections describe the actions of each helicopter type in each of the operational modes.

b. Autonomous Mode.

(1) Scout helicopters. The scout helicopter (SH) in the autonomous mode is utilized only in the command and control mode. Each SH executes a series of popups to observe the battlefield and detect enemy elements. Based on its own detections, the SH provides information about the threat force to the attack helicopters (AH). The AHs utilize the information from the SHs to detect enemy elements more rapidly and maintain the desired standoff range. See figure 1 for a schematic diagram of SH actions.

(2) Attack helicopters.

(a) The AH starts its event by executing a near vertical popup to a hover position at the maximum altitude allowed for its present operations area. It then executes a series of random evasive actions while searching for enemy elements. The time required to make detections is based on the DYNTACS(X) long range detection equation utilizing the appropriate helicopter optics and the field of view available to the pilot. The AH remains in the search mode for a varying length of time. This time decreases as more threat elements establish line of sight to the AH and as the threat closes the range to the AH.

(b) If the AH has failed to make a detection before its search time expires, it remasks, relocates itself in its operations area, and unmasks for another attempt at detecting an enemy element.

(c) When the AH does detect one or more enemy elements it selects the highest priority target available for attack. The priority is based on vehicle type, time and target of the vehicle's last firing, and whether the vehicle is already receiving fire.

(d) After selecting a target, the AH calculates an attack path using the minimum altitude required to maintain line of sight to the target and attempts to achieve missile lockon using the offset lasing technique. If the selected target breaks line of sight prior to lockon, the AH has the option of selecting an alternate target anywhere on the battlefield to which line of sight exists. After achieving lockon against the original or alternate target, the AH switches lase to the target and launches a missile. The missile flight path is based on missile type. XRTOW and laser beam rider are flown on a line-of-sight trajectory. Other missiles are flown on a "ballistic" path to account for the greater seeker visibility associated with the greater altitude with this type of missile. As the missile flies along its path, line of sight between the missile and target is checked each 0.3 second. Line of sight between the

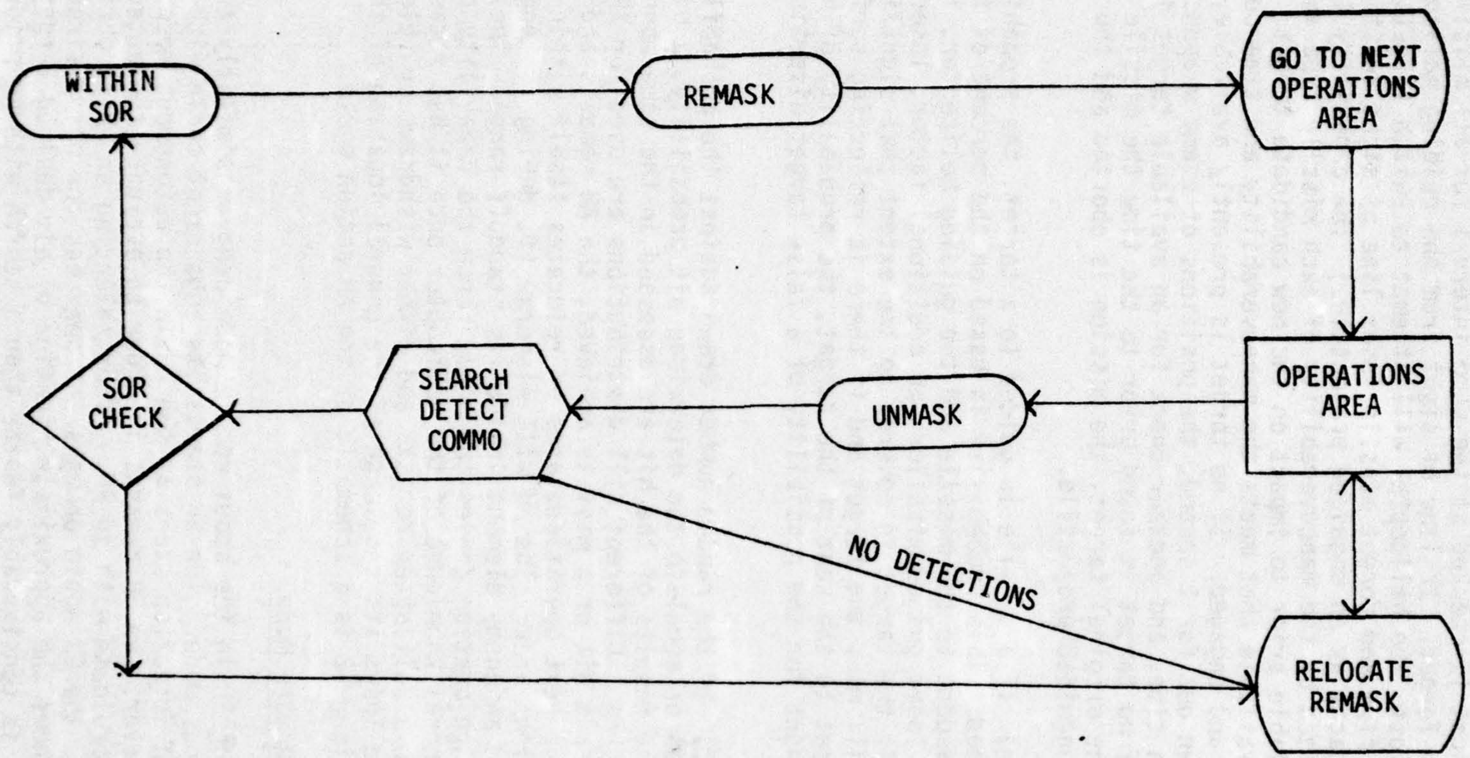

Figure 1. Scout Helicopter Search Only Operational Schematic

missile and target is checked at the same interval for all missile types except fire and forget. If line of sight from the guiding helicopter to the target is lost, the helicopter will attempt to switch targets in flight. (If a fire and forget missile loses line of sight to its target, the missile impacts as an unguided projectile.) The capability to switch targets is limited by the maneuverability of each missile type and the time of flight available prior to impact on the new candidate target. If there is a vehicle available that meets the maneuverability and time constraints, it is selected and engaged. If no target is presently available, the missile is flown out for 1 second, the positions of enemy weapons are extrapolated in time, and another check for an available target is instituted. If no target is found prior to the time the missile reaches the range of the original target, the mission is aborted and the missile impacts as an unguided projectile.

(e) If a missile is guided to a target, the probability of hit is determined. This probability is based on the percent of the target covered with respect to the missile and the guiding helicopter, if any. In the case of laser guided missiles, an additional factor, laser spillover, is included. If the target is covered to the extent that significant laser energy will miss the target and if there is reflecting surface within 5,000 feet to the reat of the target, the probability of hit is reduced to account for the possibility of a false target diverting the missile.

(f) If the random number drawn against the probability of hit is less than or equal to the determined hit probability, a hit is achieved and the results of the hit are assessed in the same manner as the ground weapons. Different kill distributions are used for XRTOW and HELLFIRE. After a hit or a miss is achieved, the AH remasks and either withdraws to the next operations area or relocates itself within the current operations area. The AH will withdraw if, during its engagement, it has detected an enemy element inside its standoff range. The potential for this rapid relocation denies the enemy force the capability of maintaining general knowledge of the helicopter once it has remasked. Therefore, when a helicopter remasks and either withdraws or relocates, the enemy force loses its knowledge of the general location of the helicopter. Figure 2 is a schematic of the AH action cycle.

c. Scout Remote Mode.

(1) The SH in the scout remote mode behaves similarly to the AH in the autonomous mode. The SH starts its engagement cycle with the same unmask and detection steps as the AH in the autonomous mode. After detection, however, the SH remasks in order to evaluate the detected targets and coordinate with an AH. After selecting an AH to participate in the mission, the SH again unmasks and searches for his desired target. Since the SH knows the approximate location of his desired target, his detection rate is considerably faster than a search with no prior

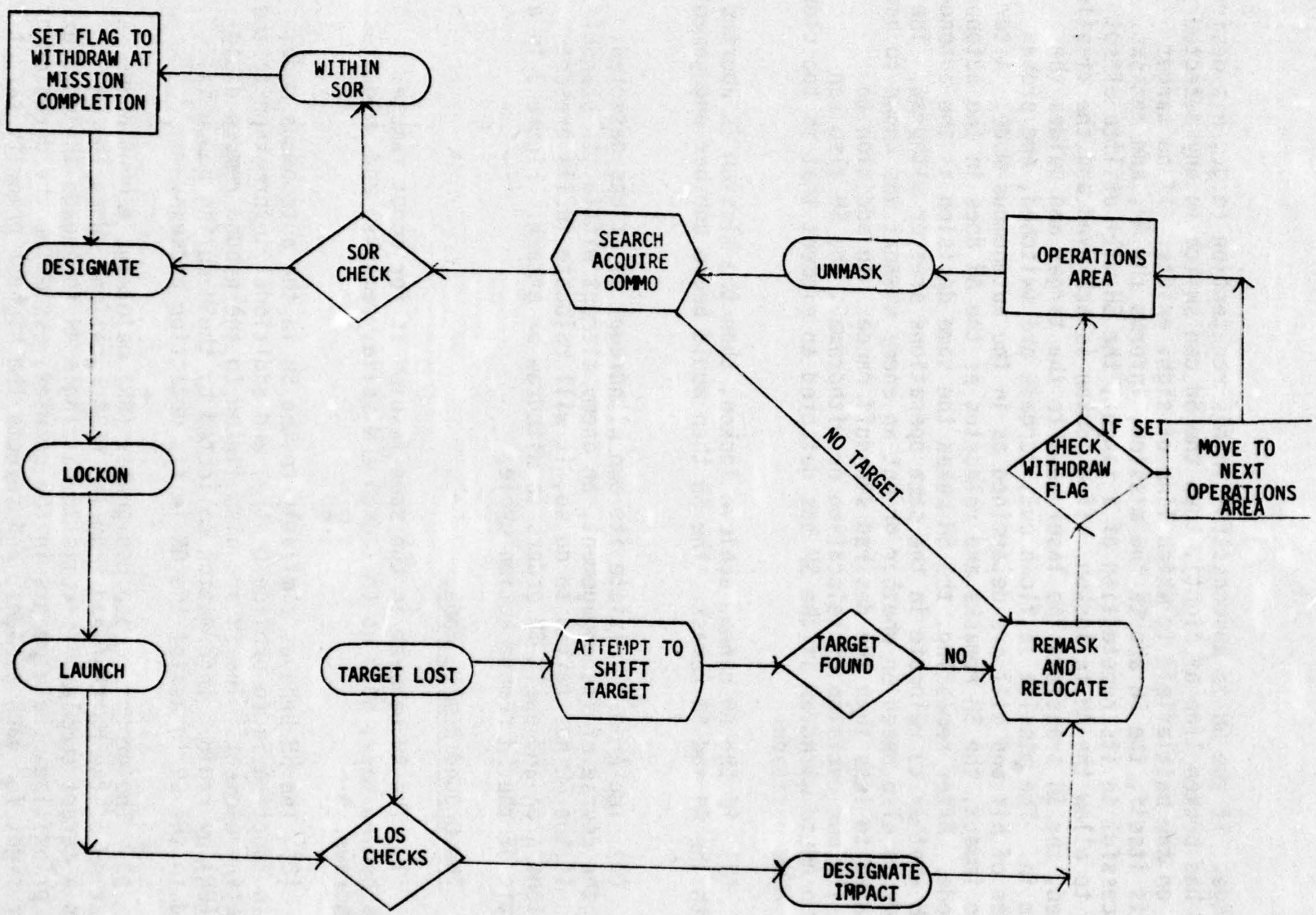

Figure 2. Hellfire Autonomous Operational Schematic

knowledge. If the SH is unsuccessful in his redetection (e.g., his desired target has broken line of sight), then the SH can switch to any detected target on the battlefield to which line of sight exists. If no target presents itself, the SH aborts the mission, informs the AH, and remasks. If successful in its redetection of a target, the SH will utilize offset lasing to allow the AH to lockon. If a lockon is achieved and the missile launched, the SH transfers the laser beam to the target and guides the missile in. The missile is flown out, targets are switched, and probabilities of hit and kill are determined as in the autonomous mode. After missile impact, the SH remasks and relocates as the AH does in the autonomous mode. After remasking, the SH makes the same decision as the autonomous AH whether to relocate in the same operations area or withdraw. The decision is also based on whether or not an enemy element was known to have penetrated to less than the desired standoff range. In addition to making its own decision of relocation or withdrawal, the SH also can order an AH to withdraw if the SH has detected an element that is too close to the AH's position.

(2) If the Ah cannot achieve lockon, then the mission is aborted and both the AH and SH remask. The SH then would begin another engagement cycle.

(3) The AH can initiate its own withdrawal if it has detected, during the course of its engagement, an enemy element within its standoff range. If the AH has failed to do so, it will relocate in its present operations area and await SH orders to withdraw or attack. Figure 3 is a schematic of the SH remote action cycle.

d. <u>The Ground Remote Mode</u>.

(1) The AH behaves in the same fashion as for scout remote: remains behind mask, pops up to launch a missile, remasks, and relocates or withdraws.

(2) The SH behaves similarly to the SH in the autonomous mode: its main function is to provide control and additional information to the designating element. The SH are also linked to the ground remote designator (GR) by radio. Information collected by theSH during popup is relayed to the GR to assist the GR in its detection process.

(3) The ground remote designator (GR) maintains a continuous observation of the battlefield from its FEBA location. When the GR detects a target complex, it calls for a single AH to engage the complex. The GR prioritizes the elements in the complex, estimates the duration of line of sight for each element, and selects the highest priority target that is expected to be visible when the AH attacks. When the AH unmasks, theGR lases using the offset lasing technique. When lockon has been achieved and the AH fires its missile, the GR shifts its laser to the target and guides the missile in. Probabilities of hit and kill are determined as in the autonomous case. The GR will also notify the AH to withdraw when enemy elements have approached within the desired standoff range. Figure 4 is a schematic of the GR remote action cycle.

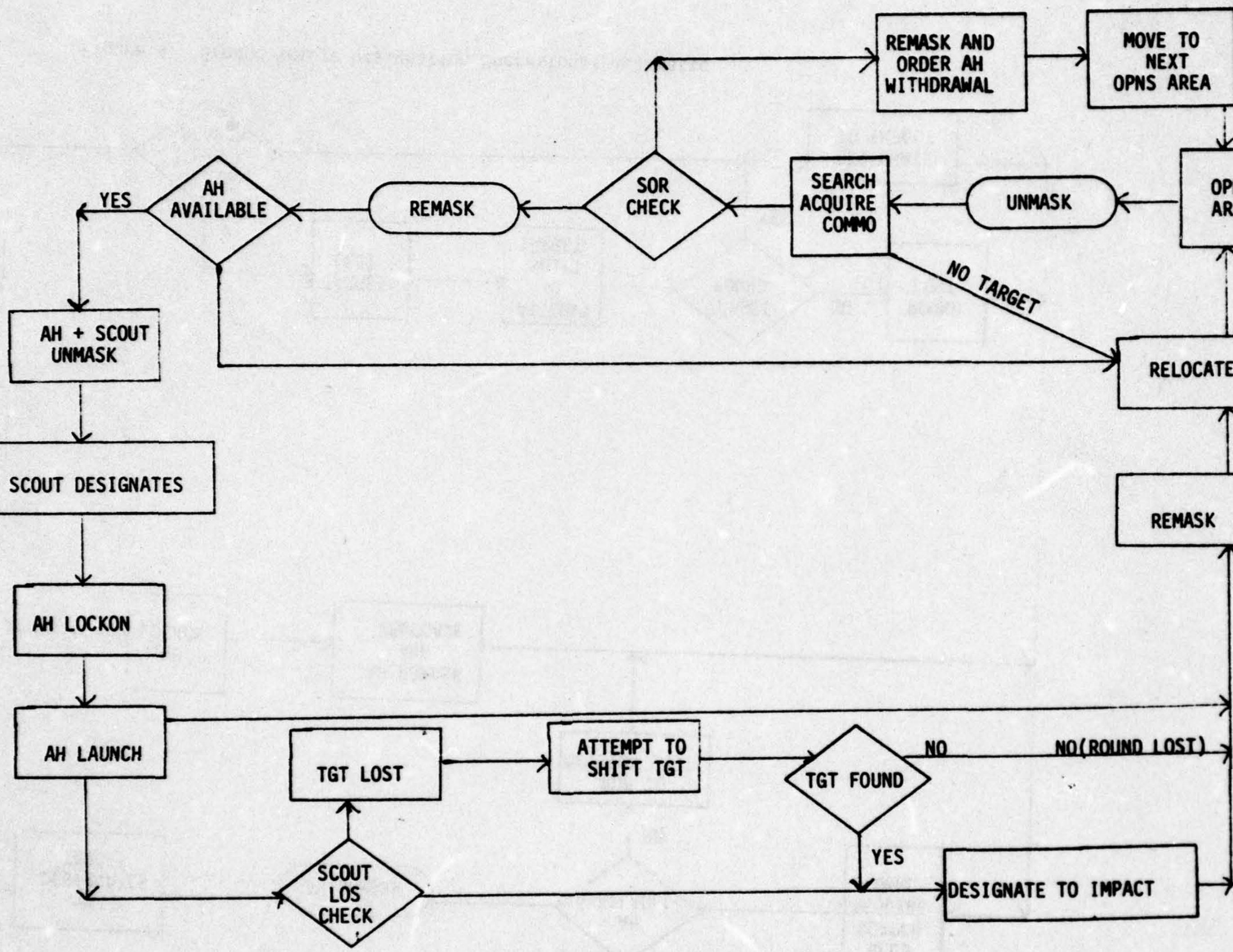

Figure 3. Scout Remote Designation Operational Schematic

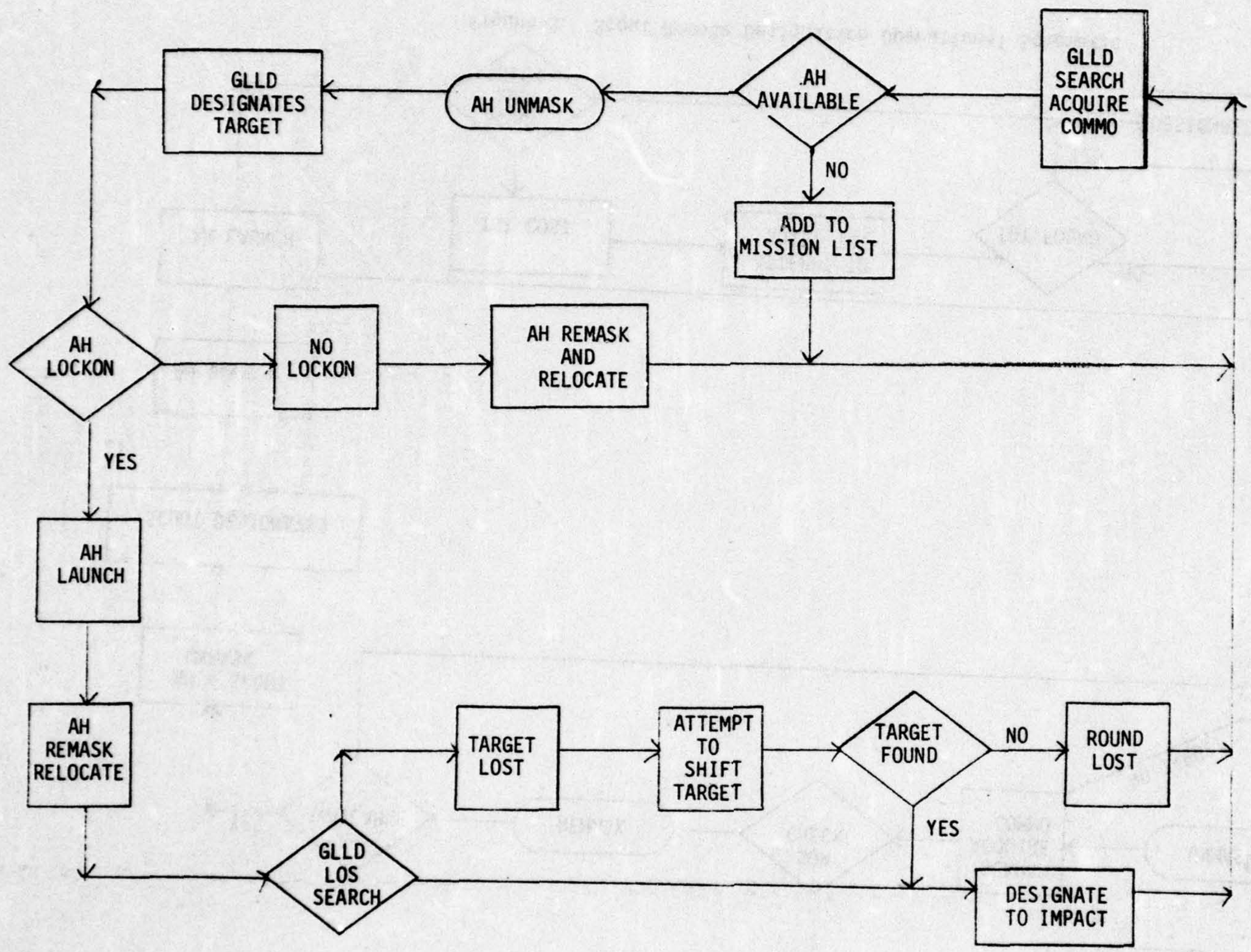

Figure 4. Ground Remote Designation Operational Schematic

REFERENCES

1. AR 66-2, The Tank Weapon System, Systems Research Group, Ohio State University, December 1966.

2. AR 69-2A, The Tank Weapon System, Systems Research Group, Ohio State University, September 1969.

3. AR 69-2B, The Tank Weapon System, Systems Research Group, Ohio State University, September 1969.

4. Automated Preparation of Digital Topographic Data, SA Group Technical Report TR 2-73, February 1973.

APPENDIX A

ENVIRONMENTAL DATA PREPARATION

1. Environmental data are prepared only when a piece of terrain is used for the first time. For all subsequent uses, the using command has the option of using the environment data as they were prepared by the original user. Although this option is appealing because it eliminates a major headache, it should be adopted only when time constraints require that every possible short cut be adopted. Instead of accepting the environmental data, the elevation map produced by MAPLOT program (inclosure A-I-a) and individual environmental overlays (inclosure A-II-a) should be produced and checked against source data.

2. At the present time DYNTACS(X) environmental descriptors have been prepared for only two areas, one in the Fulda Gap, Germany, and one on Fort Hunter-Liggett, California. Therefore, the present user of DYNTACS(X) must either place his scenario in one of these two terrains or prepare an entire environmental data base for a new area. The remainder of this appendix will be of interest to those who are considering the preparation of a new set of environmental data.

3. Environmental data can be separated into elevation data and descriptive environmental overlays. The elevation data are normally provided by either Defense Mapping Agency (DMA) or Waterways Experimentation Station (WES). At this time DMA can supply only elevation tapes. These tapes contain elevation data derived from 1:50,000 scale maps. One tape contains the elevations at 12.5 meters intervals for an area of 1 degree of longitude by 1 degree of latitude. The elevation of the area of concern must be extracted from the information provided by the DMA tape. A possible procedure for performing this extraction is explained at annex A-I. DMA provides these tapes at no cost to the user.

4. WES will provide elevation information in any format required on cards or tape under a procurement contract. Since the user can specify the data format and will receive only the elevation data required, he can avoid the problem of extracting the needed information from a mass of data. One must recall that the elevation resolution must be fine enough to allow an estimation of the microterrain standard deviation (see annex B-II). This must be taken into account when specifying the resolution required from WES. However, WES must be reimbursed for its effort and the funds (approximately $2,000) must be made available.

5. DMA in coordination with CCSS directorate, CACDA, Fort Leavenworth is exploring the possibility of providing environmental information in addition to elevation data. The two agencies are compiling a list of required information for several land combat models. DMA intends to develop the capability to satisfy all the environmental data needs of several of the Army's models. If DMA can fulfill its goal, then DYNTACS(X)

users will be able to receive a full data package containing all required environmental data for any area in the world. When this capability is realized, one of the main constraints (limited terrain) now imposed on the DYNTACS(X) model will no longer exist.

6. After the elevation matrix has been prepared, the accuracy of the matrix should be checked by the use of a program called MAPLOT and a topographical map. The MAPLOT program (See chapter 5 and annex E, Automated Preparation of Digital Topographic Data, SA Group Technical Report TR 2-73, Feb 73, and inclosure A-1-d, this report) will produce a plot of the contour lines defined by the prepared elevation data. By properly adjusting the input parameters one can produce a plot that has the same scale and contour interval as a reference topographical map. By superimposing the computer produced plot and the topographic map, one can normally detect significant mistakes in the input elevation data.

7. Once the elevation data have been procured and verified, the environmental overlays are produced. (An explanation of the environmental overlays starts on page 2-18, AR 69-2A, The Tank Weapon System, September 1969. It should be noted that the maximum number of overlapping figures considered has been raised to 50 (pg 2-19) and that the information originally contained in COMMONS LBINTL and LRINTL is now contained in COMMON TD.) These overlays are normally produced from a detailed terrain analysis, which is usually performed by WES.

8. In the past, there has been too little guidance and direction provided to WES. This lack of guidance normally produces a wealth of detailed information having little or no bearing on the qeustions that need to be addressed in order to prepare DYNTACS(X) input. For example, DYNTACS(X) only needs the height, density, and diameter of the vegetation. Collecting reams of information measuring the thickness of primary, secondary, etc. branchings from the main trunk is not only unnecessary but may prevent the required data from being collected. A concerted effort must be made to limit the terrain analysis to an examination of those environmental factors portrayed in DYNTACS(X). This will not only increase the accuracy of the analysis but will also probably result in a decrease in cost by eliminating unnecessary detail. The form of the report on the terrain analysis should also conform to the DYNTACS(X) requirements. A classification system based on the variables DYNTACS(X) uses for vegetation, soil type, and surface roughness should be required. A series of overlays showing the location of each type of vegetation, soil type, and surface roughness should be included in the report. (See page 2-22, Report AR 69-2A, The Tank Weapon System, Systems Research Group, Ohio State University, September 1969 for a list of environmental variables used in DYNTACS(X).

9. A properly conducted terrain analysis should be sufficient to allow the preparation of the environmental overlays. However, a 1:25,000 scale topographic and an aerial photograph of the surface in question could be helpful in resolving questions about the area. These should be made available, if possible.

10. The environmental overlays should be prepared with a high degree of accuracy. Many of the tactical decisions and decision rules are predicated on a map analysis. Since military people seem to have difficulty understanding and interpreting computer prepared maps, these map analyses will probably be done using topographic maps. If these map analyses are to prove useful, the terrain as "seen" by the computer should closely resemble the actual terrain. Because this resemblance to the actual terrain is so important, it is necessary to take steps to insure that the environmental figures have been coded properly. One procedure for doing this is to prepare a plot of each of the environmental overlays and compare each plot with its respective original overlay. A plot program for accomplishing this is included at annex A-II.

11. The general approach to coding the environmental overlays that has been used before is to prepare one set of figures (circles and parallelograms) for each environmental characteristic (soil type, surface roughness, etc.). This approach will mean that, in general, each figure will have only one non-zero index associated with it. The actual selection of the figures used to describe each environmental characteristic is done by judgment. To facilitate this selection, an overlay for a particular terrain characteristic is prepared on the same scale as an available topographic map. The overlay is superimposed over the topographic map, and geometric figures are selected to represent the different areas of interest. The grid coordinates of the corners of each parallelogram and the center and radius of each circle are then read from the topographic map. These grid coordinates are then provided to the FEATUR program, which transforms the coordinates into DYNTACS(X) input. The FEATUR program is at annex A-III.

12. The following is a list of suggestions or pointers to be considered when preparing input for the FEATUR program:

a. It is important to order the coordinates of the corners of a parallelogram properly. Any order is acceptable provided that the corners are listed in either clockwise or counterclockwise order. For example, in figure A-I the coordinates could be listed in any of the following orders: 1234, 3412, or 3214. However, 3124 would be an unacceptable order. The FEATUR program adjusts the fourth coordinate in any list to produce an accurate parallelogram. Although the FEATUR program has a test for coordinates in an improper sequence, the mathematical accuracy in coordinates required to allow identification of this problem makes the test ineffective. Consequently, entering the coordinates in order 3124 might produce parallelogram 3125 instead of 1234, as desired.

b. The following is another technique predicated on the adjustment of the fourth coordinate listed. The primary use of the geometric figures is to define boundaries between areas of different index values. The

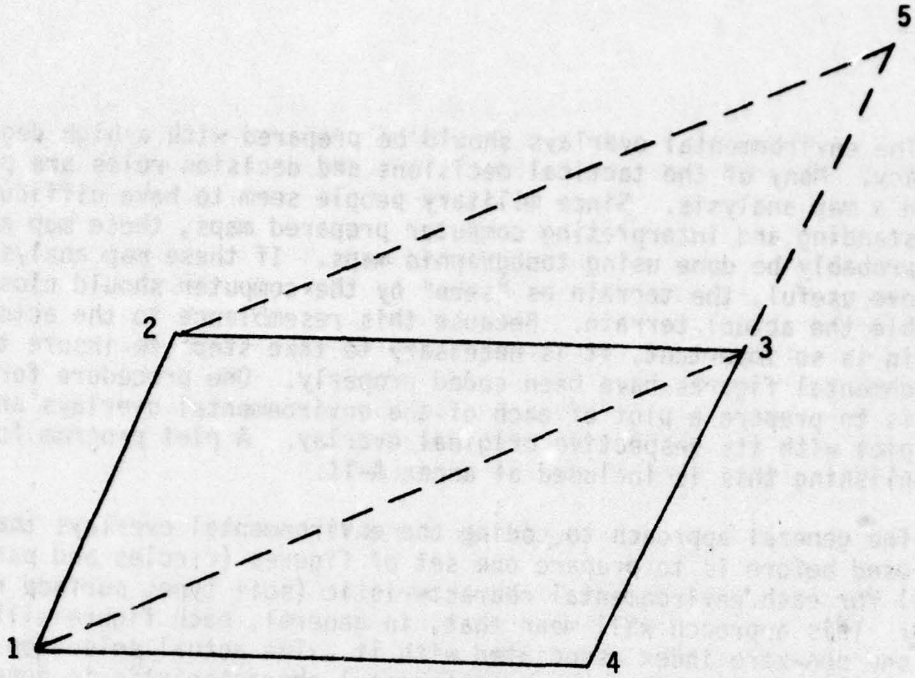

Figure A-1. Numbering Sequence for FEATUR Parallelograms

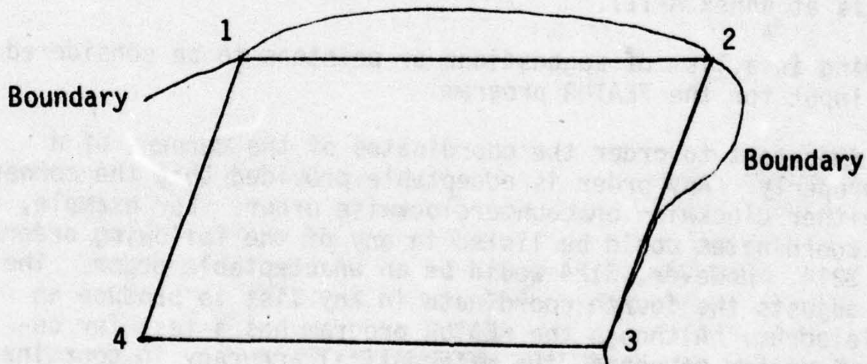

Figure A-2. Boundary Consideration for FEATUR Parallelograms

parallelogram in figure A-2 is being used to define part of a boundary. If the coordinates for this figure are entered in order 2341 and an adjustment of the last coordinate is required, the position of point 1 will be modified. This will result in an adjustment to the boundary being described. However, if the coordinates are entered in order 1234 or order 3214, point number 4 will be adjusted and the desired boundary description will be maintained. Therefore, when recording coordinates of a parallelogram, one should take care to list the point that is interior to the area being described in the fourth position.

c. If dynamically emplaced minefields are employed, sufficient (approximately 60) extra parallelograms and circles must be provided to describe these features. This will have implications in the dimensions of several environment related commons or variables.

d. In the case of figures depicting heavy vegetation, an exception may be made to the general rule of one non-zero index value per figure. In this case, the speed of travel through the vegetation may be limited in addition to describing the vegetation itself. If this is the case, the appropriate rough terrain code may be included with the vegetation code for the appropriate figures.

e. Areas of vegetation can also be coded as forest features. (See description of cover fraction starting on page 2-49, Report AR 69-2A, The Tank Weapon System, Systems Research Group, September 1969.) When an area of vegetation would be expected to totally block line of sight, that area should be coded as a forest feature by placing the alpha character F in card column 80 on the data card for FEATUR. Since forest features totally obscure line of sight, care should be taken in assigning the forest designation to areas near a defensive site. These forest features close to the defensive weapons may unrealistically interrupt the line of sight of the defensive weapons.

f. The index value used for minefields has no relationship to the index system used for other figures. The minefield index is the density of the minefield times 100,000.

g. Manmade objects (cities, towns, towers) can be coded as "forest" features to allow them to obscure line of sight where appropriate.

h. Whenever possible, circles should be used to describe areas on the terrain. The use of circles will speed up the machine procedure used to identify which figures are superimposed over a given location.

i. Consideration may be given to assigning background parameter values to the highest index value in each environmental category. This procedure may lead to efficiencies when describing unusual areas. In this case, depicted in figure A-3, one could use a figure with a high index value and background parameter values to "subtract" an area of

lower index value. Circle A with radius R has index value 3. Circle B with radius S has index value 5 and background parameter values. Since only the highest index value is used for one environmental characteristic, the circle B cancels out part of circle A. If this method were not used, the area to be described would require several parallelograms and circles for its description.

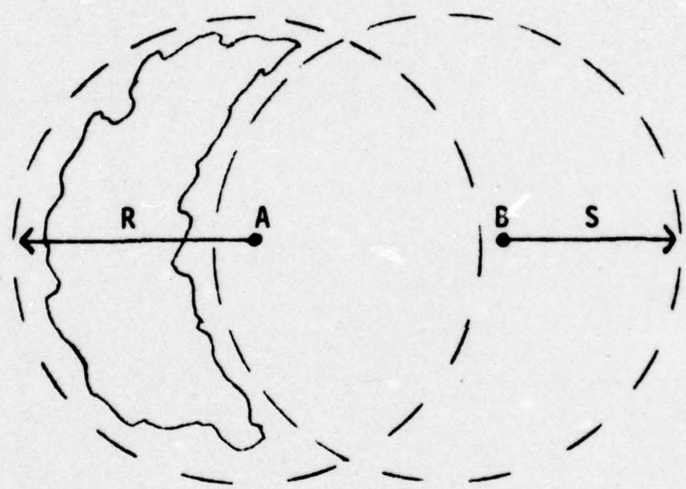

Figure A-3. Subtracting Environmental Features

ANNEX A-I

CACDA Elevation Data File Processing

1. Elevation Data are received from Defense Mapping Agency Topographic Center (DMATC) Washington, D.C. These data are being digitized at each 0.01 inch on the map and equate to a ground distance or interval of 12.5 meters. These are also based on the Universal Transverse Mercator grid system.

2. The following programs are used to convert the elevation data from the UNIVAC format in which the data are received from DMATC to the standard Control Data Corporation (CDC) format utilized by the CDC computer located at Fort Leavenworth, Kansas:

a. UATA1: This program is used to transfer the Elevation Data from the UNIVAC tape supplied by DMATC to a CDC tape maintained by the TRADOC Data Processing Field Office (DPFO) at Fort Leavenworth, Kansas. (See Inclosure A-I-a.)

b. UATA2: This program converts the tape created in UATA1 from the UNIVAC format to the CDC standard format. (See Inclosure A-I-b.)

c. UATA3: This program is used to extract from the tape file created in UATA2 an elevation matrix that represents a desired land area and grid interval. A control card (described in the program listing) is required that describes the UTM coordinates of the area to be extracted and the grid interval in multiples of 12.5 meters. (See Inclosure A-I-c.)

d. UATA4: Program used to produce a tape that can be used as input to the CAL COMP plotter to create a contour map of the area extracted in program UATA3. Control card information is provided in the program listing. (See Inclosure A-I-d.)

e. UATA5: Program is used to join arrays of elevation matrices into a single elevation matrix file. Program description and control card information is included within the program description. (See Inclosure A-I-e.)

Inclosure A-I-a

Transfer of Elevation Data to CDC Tape
(UATA1)

```
UATA1,T500,MT1,NT1.   INITIAL PROGRAM TO READ UNIVAC TAPE FROM DMATC
TASK,TN=IUAMNT,TA=21702,WP=57,OS=ATJACAM,TP=TS.
PAUSE. UNIVAC TAPE IS INPUT ON UNIT 5 (7 TRACK)
VSN,TAPE5=3016.   *INPUT** 7 TRACK        FROM  DMATC
REQUEST,TAPE5,MT,HY,L.
VSN,TAPE6=SAVE. *OUTPUT 9 TRACK*
PAUSE.LABEL=G5801,PI=HH,DEN=PE,TRK=9,JOB=JATA1.
LABEL,TAPE6,W,D=PE,L=G5801.
FTN,L=0.
LGO.
      PROGRAM MAPS(OUTPUT,TAPE5,TAPE6,TAPE61=OUTPUT)
      DIMENSION IARRAY(692),JARRAY(8)
      DATA  IEOF/1254626150B/,IEOI/1255131150B/
      IC=0
      DO 10 I=1,2
      BUFFER IN(5,1)(JARRAY(1),JARRAY(8))
      IF (UNIT(5)) 20,30,21
   21 WRITE(61,917)
      GO TO 30
   20 WRITE(61,910) JARRAY
  910 FORMAT(1H ,5020/1X,5020)
      BUFFER OUT(6,1)(JARRAY(1),JARRAY(8))
      IF(UNIT(6)) 10,30,21
   10 CONTINUE
   11 BUFFER IN(5,1)(IARRAY(1),IARRAY(692))
      IF (UNIT(5)) 63,70,62
   62 WRITE (61,917)
      WRITE (61,920) IARRAY
   30 WRITE (61,904)
  904 FORMAT(32H PARITY CHECK  JOB ENDS ABNORMAL)
      STOP
  920 FORMAT((1H ,(1X,020,1X,020,1X,020,1X,020,1X,020,1X,020)))
   63 JSHFT= SHIFT(IARRAY(1),-30)
      IF (JSHFT.EQ. IEOF)  GO TO 71
      IF(JSHFT.EQ. IEOI) GO TO 72
      IF (IC.GE.10) GO TO 60
      IC=IC+1
      WRITE(61,920) IARRAY
   60 BUFFER OUT(6,1) (IARRAY(1),IARRAY(692))
      IF(UNIT(6)) 11,30,21
   71 WRITE (61,900)
```

```
900 FORMAT(34H END OF EOF BY CHECKING EOF RECORD)
    GO TO 60
 72 WRITE(61,901)
901 FORMAT(23H END OF INFORMATION CHK)
    BUFFER OUT (6,1)  (IARRAY(1), IARRAY(692))
    IF(UNIT(6)) 31,30,21
31  WRITE(61,920) IARRAY
 70 WRITE(61,930)
930 FORMAT(1H ,13HTHATS THE END)
    ENDFILE 6
    REWIND 6
    WRITE(61,940)
940 FORMAT(1H1,18HCHECK OUT CDC TAPE)
    DO 15 L=1,2
    BUFFER IN(6,1)(JARRAY(1),JARRAY(8))
    IF(UNIT(6)) 14,66,16
 16 WRITE(61,917)
917 FORMAT(1H ,32HTHIS RECORD HAD I/O PARITY ERROR)
 14 WRITE(61,910) JARRAY
 15 CONTINUE
    IC=0
 25 BUFFER IN(6,1)(IARRAY(1),IARRAY(692))
    IF (UNIT(6)) 26,66,69
 69 WRITE (61,917)
 68 WRITE(61,920) IARRAY
    GO TO 25
 26 IF(IC.GE.10) GO TO 25
    WRITE(61,920) IARRAY
    IC=IC+1
    GO TO 25
 66 WRITE(61,921)
921 FORMAT(1H ,21HEND OF FILE BY EOF CK)
    STOP
    END
```

Inclosure A-I-b

Modification of Elevation Data to CDC Format
(UATA2)

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```
UATA2,T70000,NT2.  CONVERT INTO CDC  60 BIT WORD STRUCTURE
TASK,TN=IUAMNT,TA=21702,WP=57,OS=ATCACAM,TR=TS.
PAUSE.  TAPE 6 IS THE OUTPUT TAPE FROM  UATA1
VSN,TAPE6=9898.  INPUT *9* TRACK
LABEL,TAPE6,R,D=PE,L=G5801.
VSN(TAPE8=SAVE)**OUTPUT TAPE**WILL GO INTO 2 REELS MAYBE
PAUSE. LABEL=G5802,TRK=9,D=PE,JOB=UATA2, TSK=IUAMNT**
LABEL,TAPE8,W,D=PE,L=G5802.
FTN,L=0.
LGO.
      PROGRAM CONVRT(OUTPUT,TAPE6,TAPE8,TAPE61=OUTPUT)
      DIMENSION IA(692), JA(8), IZ(2307)
      DATA IEOF/1254626158/,IEOI/1255131158/
      IN1B=77770000000000000000B
      IN2A=00000000000000001777B
      IN2B=77000000000000000000B
      IN1A=00000000000000000017B
C
C  BUFFER IN HEADER RECORDS AND BYPASS
C
      DO 10 I=1,2
      BUFFER IN(6,1) (JA(1) ,JA(8))
      IF(UNIT(6))9,99,9
    9 CONTINUE
   10 CONTINUE
C
C BUFFER IN ELEVATION RECORDS AND CONVERT TO CDC6000 WORD STRUCTURE
C
      ICNT=0
   20 DO 21 I=1,2307
   21 IZ(I) = 0
      BUFFER IN(6,1) (IA(1),IA(692))
      IF (UNIT(6)) 30,99,30
C
   30 JSHIFT = SHIFT(IA(1),-30)
      IF(JSHIFT.EQ.IEOF) GO TO 96
      IF(JSHIFT.EQ.IEOI) GO TO 96
      ICNT= ICNT+1
C
C  THE ABOVE CHECKS FOR END OF FILE AND END OF INFORMATION
C
C
C  BUILD CDC RECORD FROM NMP TAPE
C  SCAN LINE X IN WORD 1 SCAN LINE Y IN WORD 2
C
      IW= SHIFT(IA(1),36)
      IZ(1) =SHIFT(IW,-48)
      IW= SHIFT(IA(1),48)
      IZ(2) =SHIFT(IW,-48)
C
C  BUILD Z COORDINATES FOR SCAN LINE
C  THIS LOOP CONVERTS 10 ELEVATIONS  FOR EACH INCREMENT
      K=3
      DO 65 L=2,690,3
      IW= SHIFT(IA(L),2)
      IZ(K)= SHIFT(IW,-44)
      K=K+1
      IW= SHIFT(IA(L),20)
      IZ(K)= SHIFT(IW,-44)
      K=K+1
      IW= SHIFT(IA(L),38)
      IZ(K)= SHIFT(IW,-44)
```

```
      K=K+1
      IW = IA(L).AND.IN1A
      IW1 = IA(L+1) .AND. IN1B
      IW= IW.OR.IW1
      IW= SHIFT(IW,56)
      IZ(K)= SHIFT(IW,-44)
      K=K+1
      IF (L .GE. 690) GO TO 65
      IW= SHIFT(IA(L+1),14)
      IZ(K)= SHIFT(IW,-44)
      K=K+1
      IW= SHIFT(IA(L+1),32)
      IZ(K) = SHIFT(IW,-44)
      K=K+1
      IW= IA(L+1).AND.IN2A
      IW1=IA(L+2).AND.IN2B
      IW = IW.OR.IW1
      IW = SHIFT(IW,50)
      IZ(K) = SHIFT(IW,-44)
      K=K+1
      IW= SHIFT( IA(L+2), 8)
      IZ(K) = SHIFT(IW,-44)
      K = K+1
      IW = SHIFT(IA(L+2),26)
      IZ(K) = SHIFT(IW,-44)
      K=K+1
      IW = SHIFT(IA(L+2),44)
      IZ(K) = SHIFT(IW,-44)
      K=K+1
   65 CONTINUE
C
C ALL DONE WITH ONE SCAN LINE
C    **FOLLOWING CODE GETS RID OF 7(S AT END OF ELEVATIONS
C
      DO 66 K=1,2307
      IF(IZ(K).EQ.-63)  GO TO 67
   66 CONTINUE
      GO TO 69
   67 CONTINUE
      KX=K-3
      DO 68 IXY=KX,K
   68 IZ(IXY)=0
   69 CONTINUE
C
C*****************
      WRITE(8,103) (IZ(N),N=3,2307)
      IF (ICNT.GE.50) GO TO 20
      GO TO 20
   96 WRITE(61,104) ICNT
  104 FORMAT(1X,35HALL DONE  NUMBER OF RECORDS READ = ,I5)
  101 FORMAT(1X,20I6)
  102 FORMAT(1X,28HBUFFER OUT I/O ERROR RECORD ,I3)
  103 FORMAT(I5)
   99 CONTINUE
      STOP
      END
```

Inclosure A-I-c

Extraction of Data from CDC Matrix
(UATA3)

```
UATA3,T700,NT1.  PREPARE ELEVATION MATRIX
TASK,TN=TUANNT,TA=21792,WR=57,OS=ATCACAM,TR=TS.
PAUSE.  TAPE 8 IS THE OUTPUT FILE FROM UATA2
VSN,TAPE8=7215=7744=9690.  INPUT FILE     FROM *UATA2*
LABEL,TAPE8,R,D=PE,L=G5302.
PAUSE. TAPE 9 IS THE OUTPT FILE(ELEVATION MATRIX)USUALLY SMALL ENOUGH FOR DISK
REQUEST,TAPE9,*PE.
FTN,L=0.
LGO.
CATALOG,TAPE9,G5303,ID=IUAMNT.
      PROGRAM BUILD(INPUT,OUTPUT,TAPE8,TAPE9,TAPE51=OUTPUT,TAPE60=INPUT)  MATRIX
      DIMENSION IZ(2305)                                                  MATRIX
      ICNT=0                                                              MATRIX
      READ(60,1000)X1,Y1,X2,Y2,X3,Y3,ID                                   MATRIX
C **CONTROL TO DESCRIBE  UTM COORDINATES OF ELEVATION MATRIX               GG
C**                   DISCRIPTION OF INPUT DATA CARD                      GG
C**CC                 DESCRIPTION                                         GG
C  1-6                X COORD OF SW CORNER OF DMATC TAPE                  GG
C  7-13               Y COORD OF SW CORNER OF DMATC TAPE                  GG
C  14-19              X COORD OF SW CORNER OF AREA TO BE EXTRACTED        GG
C  20-26              Y COORD OF SW CORNER OF AREA TO BE EXTRACTED        GG
C  27-32              X COORD OF NE CORNER OF AREA TO BE EXTRACTED        GG
C  33-39              Y COORD OF NE CORNER OF AREA TO BE EXTRACTED        GG
C  40-41              INTERVAL TO BE EXTRACTED(IN MULTIPLES OF 12.5 METERS) GG
C                     01 = 12.5                                           GG
C                     02 = 25.0                                           GG
C                     03 = 37.5                                           GG
C                     .                                                   GG
C                     .                                                   GG
C                     08 = 100.0                                          GG
C                     ETC                                                 GG
 1000 FORMAT(3(F6.0,F7.0)I2)                                              MATRIX
      IX4=(X2-X1)/12.5                                                    MATRIX
      IY4=(Y2-Y1)/12.5                                                    MATRIX
      IX5=(X3-X2)/12.5                                                    MATRIX
      IY5=(Y3-Y1)/12.5                                                    MATRIX
      NXS=IX5/ID                                                          MATRIX
      NYS=(IY5-IY4)/ID+1                                                  MATRIX
      IF(IX4.LT.1) IX4=1                                                  MATRIX
      IF(IY4.LT.1) IY4=1                                                  MATRIX
      IF(IX5.LT.1) IX5=1                                                  MATRIX
      IF(IY5.LT.1) IY5=1                                                  MATRIX
      IF(NXS.LT.1) NXS=1                                                  MATRIX
      IF(NYS.LT.1) NYS=1                                                  MATRIX
      WRITE(51,1002)X1,Y1,X2,Y2,X3,Y3,ID                                  MATRIX
```

```
 1002 FORMAT(1X,3(F7.0,2X,F8.0)2X,I7)                                   MATRIX
      WRITE(61,1003)IX4,IY4,IX5,IY5,NXS,NYS                             MATRIX
 1003 FORMAT(1X,6(I5,5X))                                               MATRIX
   20 DO 30 I=1,IX4                                                     MATRIX
      READ(8,1001)IZ                                                    MATRIX
      IF(EOF(8)) 99,30                                                  MATRIX
   30 CONTINUE                                                          MATRIX
   35 WRITE(9,1001) (IZ(J),J=IY4,IY5,ID)                                MATRIX
 1001 FORMAT(I5)                                                        MATRIX
      DO 41 I=1,ID                                                      MATRIX
      READ(8,1001)IZ                                                    MATRIX
      IF(EOF(8)) 99,41                                                  MATRIX
   41 CONTINUE                                                          MATRIX
      ICNT=ICNT+ID                                                      MATRIX
      IF(ICNT.GE.IX5)   GO TO 99                                        MATRIX
      GO TO 35                                                          MATRIX
   99 CONTINUE                                                          MATRIX
      ENDFILE 9                                                         MATRIX
      REWIND 9                                                          MATRIX
   45 DO 50 I=1,2305                                                    MATRIX
   50 IZ(I) = 0                                                         MATRIX
      READ(9,1001) (IZ(I),I=1,NYS)                                      MATRIX
      IF(EOF(9)) 999,60                                                 MATRIX
   50 WRITE(51,1005) (IZ(I),I=1,NYS)                                    MATRIX
 1005 FORMAT(1X,20I5)                                                   MATRIX
      GO TO 45                                                          MATRIX
  999 STOP                                                              MATRIX
      END                                                               MATRIX
51415456054785405005619000542000562400008
```

Inclosure A-I-d

MAPLOT Program
(UATA4)

```
UATA4,T500,NT1.  PLOTTING ROUTINE  **MAPLOT**
TASK,TN=IUAMNT,TA=21702,WP=57,OS=ATCACAM,TR=TS.
ATTACH,PLT3LIB,ID=CDCSYS.
ATTACH,PLOTLIB,ID=CDCSYS.
PAUSE.  THE INPUT(TAPE10)  IS THE TAPE9 THAT WAS CREATED IN UATA3
ATTACH,TAPE10,TAPE9,ID=TETAM.
PAUSE.  TAPE 2 IS THE OUTPUT THAT WILL GO TO THE CALCOMP PLOTTER
VSN,TAPE2=SAVE.  TAPE 2 WILL BE PLOTTED
PAUSE.L=PLOTHL,DEN=PE,PI=HOW,TN=TETAM,OS=ATCACAMJOB=UAT00.
REQUEST,TAPE2,NT,SV.
LIBRARY,PLOTLIB,PLT3LIB.
FTN,L=0.
LGO.
PAUSE. TAPE 2 TO PLOTTER**11 INCH PAPER**BALL POINT**
      PROGRAM MAPLOT(INPUT,OUTPUT,TAPE2,TAPE10,TAPE1=INPUT,TAPE31)
C     LANGUAGE:     FORTRAN IV
C
C       WHEN DIMENSIONING ARRAY M, THE DIMENSIONS MUST MATCH INPUT ARRAY
C      SIZE.
C
C      DIMSINSIONS X, Y, Z, EQUAL THE TOTAL WORDS REQUIRED FOR ARRAY M
C       FOR INSTANCE IF M(10,20) THEN X(200) OR 10*20 FOR TOTAL WORDS.
C      ARRAYS XX, YY, AND ZZ WILL BE THE SAME DIMENSIONS AS M.
C      ALL CARDS THAT HAVE TO BE CHANGED BY THE PROGRAMMER FOR EACH
C       DIFFERENT MAP AREA WILL BE SEPARATED BY SLASHES /////////////////
C///////////////////////////////////////////////////////////////////////
C///////////////////////////////////////////////////////////////////////
C
C      CARE MUST BE TAKEN TO INSURE THAT THE
C      RELATIONSHIP  E=DX*DELTAV ( LAST PARAMETER
C      IN AXIS CALL ) IS TRUE.
C
C****************SPECIAL NOTE***************
C      THE DIMENSION OF IBUF IS ARBITRARY.  THERE
C      IS NO GUARANTEE THAT IT WILL BE SUFFICIENT
C      TO HOLD ALL PEN COMMANDS.  THE LENGTH
C      REQUIRED IS A FUNCTION OF THE NUMBER OF
C      COUNTOUR LINES DRAWN (IE A FUNCTION OF THE
C      COUNTOUR INTERVAL AND THE DIFFERENCE BETWEEN
C      ZMAX AND ZMIN).
C
C           ***** INPUT PARAMETERS *****
C   X,Y    - X AND Y PLOTTER COORDINATES(INCHES) OF POINTS
C   Z      - Z VALUES OF POINTS
C   NR     - NUMBER OF ROWS IN X, Y AND Z
C   NC     - NUMBER OS COLUMNS IN X, Y AND Z
C   CNTRVL- CONTOUR INTERVAL, SAME UNITS AS Z
C   *** NOTE, X, Y AND Z MUST MUST BE DIMENSIONED NR,NC
C           ***** INTERNAL PARAMETERS *****
C   DTFL   - SQUARE OF DISTANCE FROM EDGE TO FIRST LABEL, INCHES
C   LC     - MAXIMUM LENGTH OF COORDINATE SAVE STRINGS
C     THE DIMENSION OF THE COORDINATE SAVE STRINGS IS NOT
C     CRITICAL.  WHEN THE VECTORS ARE FULL, THE PROGRAM
C     USES ALL BUT THE LAST TWO PAIRS OF COORDINATES IN
C     XC AND YC TO DRAW A PARTIAL CONTOUR LINE. IT THEN
C     TRANSFERS THE LAST TWO PAIRS OF COORDINATES TO THE
C     FIRST TWO LOCATIONS AND FILLS THE XC AND YC VECTORS
C     AGAIN.
C   XC,YC - COORDINATE SAVE STRINGS, DIMENSIONED LC
C
C
C*****************************LIST OF VARIABLES  **********************
```

```
C
C     BIAS -    AN ARBITRARY POSITIVE NUMBER ADDED TO THE X AND Y
C               MATRICES TO MAKE ALL ENTRIES STRICTLY POSITIVE.
C     CNT  -    ELEVATION OF THE CONTOUR LINE BEING DRAWN
C     CNTRVL -  CONTOUR INTERVAL, SAME UNITS AS Z.
C     DB   -    SQUARE OF DISTANCE FROM CONTOUR START TO LAST PEN POS
C               SPACE AVAILABLE FOR CONTOUR LABEL IN X DIRECTION.
C     DE   -    SQUARE OF DISTANCE FROM CONTOUR END TO LAST PEN POSIT
C               OR SPACE AVAILABLE FOR CONTOUR LABEL IN Y DIRECTION
C     DLTA -    INCREMENT ADDED TO ELEVATIONS WHEN THEY EXACTLY EQUAL
C               DECISION PARAMETER
C     DIFL -    SQUARE OF DISTANCE FROM EDGE TO FIRST LABEL IN INCHES
C     DX        DUMMY VARIABLE USED TO INITIALIZE X-MATRIX IN MAIN PR
C     DXL  -    SPACE IN X DIRECTION BETWEN CONTOUR LINE AND LABEL
C     DY        DUMMY VARIABLE USED TO INITIALIZE Y-MATRIX IN MAIN PR
C     DYL  -    MINIMUM DISTANCE IN Y DIRECTION WHICH WILL ALLOW
C               A CONTOUR TO BE LABELED.
C     E         COMMON VARIABLE
C     FLAB -    INDICATOR VARIABLE: DETERMINES WHETHER CNT IS POSITIV
C               OR NEGATIVE
C     HCL  -    HEIGHT IN INCHES OF CHARACTERS IN LABEL.
C               SHOULD BE MULTIPLE OF 0.07.
C     IBUF(4081) STORAGE LOCATION FOR PEN POSITIONS
C     INC  -    VALUE OF THE INCREMENT APPLIED TO THE SUBSCRIPT OF THE
C               AND YC VECTORS WHEN DRAWING A CONTOUR LINE.
C               VALUE WILL BE 1 OR -1.
C     ITYP -    VARIABLE ADDRESS NAME IN SUBROUTINE CGTOUR.
C     K    -    COUNTER USED TO TERMINE DRAWING OF CONTOUR
C     KCNMAX -  NUMBER OF CONTOUR LINES BETWEEN ZERO AND ZMAX. USED AS
C               A DECISION VARIABLE TO TERMINATE SUBROUTINE CGTOUR.
C     KCNT -    NUMBER OF CONTOUR LINES BETWEEN ZERO AND ZMIN. USED AS
C               A COUNTER TO RECORD THE NUMBER OF CONTOUR LINES DRAWN
C     KEMP -    INDICATOR VARIABLE: DETERMINES WHETHER A LABEL IS REQU
C               FOR A CONTOUR LINE.
C     KPD  -    INDICATOR VARIABLE THAT CONTROLS PEN POSITION IN PLOT
C     KS   -    COUNTER USED WHEN DETERMINING THE TRACE OF A CONTOUR
C               LINE.
C     KSM  -    INDICATES WHETHER SMOOTHING IS USED. KSM.GT.0 IMPLIES
C     KSN  -    A COUNTER USED AS A DECISION VARIABLE IN SUBROUTINE CG
C               EQUAL TO NUMBER OF ROWS IN X,Y, AND Z MULTIPLIED BY NU
C               OF COLUMNS  MINUS ONE: NR*(NC-1)9
C     KSNP1-    A COUNTER USED AS A DECISION VARIABLE IN SUBROUTINE CG
C               EQUAL TO KSN PLUS ONE.
C     KSX       AUXILLIARY COUNTER USED DURING SEARCH OF THE INTETUOR
C               Z MATRIX.
C     KS1  -    AUXILLIARY COUNTER USED DURING SEARCH OF THE EDGES
C               OF THE Z MATRIC.
C     LC   -    MACIMUM LENGTH OF VECTOR HOLDING THE COORDINATES OF
C               A CONTOUR LINE PRIOR TO DRAWING.
C     LCS  -    DEFAULT VALUE FOR LC IN SUBROUTINE CGTOUR
C     LCSS      COUNTER USED AS A SUBSCRIPT FOR XC AND YC VECTORS.
C     LDRET -   VARIABLE ADDRESS NAME IN SUBROUTINE CGTOUR.
C     LGTH -    TOTAL LENGTH OF X,Y, AND Z MATRICES (NR*NC)
C     LSPET     VARIABLE ADDRESS NAME IN SUBROUTINE CGTOUR.
C     LZH       ADDITIONAL SUBSCRIPT USED TO INDICATE THE HIGHER ELEVA
C               USED IN INTERPOLATION
C     LZL       ADDITIONAL SUBSCRIPT USED TO INDICATE THE LOWER ELEVAT
C               IN INTERPOLATION
C     LZ1 THUR  LZ4- VARIABLE USED AS SUBSCRIPTS FOR THE X,Y, AND Z MA
C               WHEN DETERMINING THE TRACE OF A CONTOUR LINE.
C     M(51,81)  ORIGINAL STORAGE LOCATION FOR ELEVATION INFORMATION
C     NACL -    DUMMY VARIABLE FOR VALUE OF NDL WHEN ARITHMETIC OPERAT
C               ARE PERFORMED ON NDL.
C     NC        NUMBER OF COLUMNS INX,Y, AND Z MATRICES.
C     NCON -    INDICATOR VARIABLE: POSITIVE WHEN THE CONTOUR LABEL HA
C               WRITTEN. ZERO OTHERWISE.
```

```
C      NCSF       AUXILLIARY INDICATOR VARIABLE USED TO ASSIGN VALUES TO NC  MA
C      NDL    -   NUMBER OF DECIMAL DIGITS IN LABELS. NDL=-1 IMPLIES         MA
C                 NO DECIMAL POINT. NDL.LT.-1 IMPLIES ABS(NDL-1)             MA
C                 DIGITS TRUNCATED FROM RIGHT                                MA
C      NENTY -    INDICATOR VARIABLE DETERMINES WHETHER:1) THE CONTOUR LINE  MA
C                 TERMINATED ON ANEDGE.2) THE CONTOUR LINE CLOSED ON ITSELF  MA
C                 3) THE XC AND YC VECTOR ARE FULL                           MA
C      NETAH -    VARIABLE ADDRESS NAME IN SUBROUTINE CGTOUR.                MA
C      NETAV -    VARIABLE ADDRESS NAME IN SUBROUTINE CGTOUR.                MA
C      NETBH -    VARIABLE ADDRESS NAME IN SUBROUTINE CGTOUR.                MA
C      NETBV -    VARIABLE ADDRESS NAME IN SUBROUTINE CGTOUR.                MA
C      NL     -   DEFAULT VALUE FOR NLC IN SUBROUTINE CGTOUR                 MA
C      NLC        USED TO INDICATE FREQUENCY OF CONTOUR LABELING, EVERY NLC  MA
C                 CONTOUR IS LABELED IF NOT A POSITIVE NUMBER, NOLABELS      MA
C      NR         NUMBER OF ROWS IN X,Y, AND Z MATRICES.                     MA
C      NTCL  -    INDICATOR VARIABLE: DETERMINES THE                         MA
C            NUMBER OF SPACES IN A CONTOUR LABEL.                            MA
C      NX     -   NUMBER OF ROWS IN X,Y, AND Z MATRICES (SAME AS NR)         MA
C      NX3    -   NUMBER OF ROWS IN X MINUS 3 (NR-3)                         MA
C      NY     -   NUMBER OF COLUMNS IN X,Y, AND Z MATRICES (SAME AS NC)      MA
C      NY         COMMON VARIABLE                                            MA
C      SL     -   SQUARE OF MINIMUM DISTANCE BETWEEN LABELS                  MA
C      TLAB  -    DUMMY VARIABLE USED TO DETERMINE A VALUE                   MA
C            FOR  NTCL.                                                      MA
C      WAVE  -    SCALE FACTOR USED TO DETERMINE "SMOOTHED" X-AND Y-COORDIN  MA
C      WCP    -   WEIGHT GIVEN TO CENTER POINT DURING SMOOTHING.             MA
C      WTCP  -    DEFAULT VALUE FOR WCP IN SUBROUTINE CGTOUR                 MA
C      X(51,81)   X-COORDINATES OF ELEVATION IN M OR Z MATRIX                MA
C      XC         THE VECTOR WHICH HOLDS THE X COORDINATES A CONTOUR LINE    MA
C                 PRIOR TO DRAWING.                                          MA
C      XL     -   X COORDINATE OF LAST PEN POSITION                          MA
C      XMAX       COMMON VARIABLE                                            MA
C      Y(51,81)   Y-COORDINATES OF ELEVATIONS IN M OR Z MATRIX               MA
C      YC     -   THE VECTOR WHICH HOLDS THE Y COORDINATES OF A CONTOUR LUN  MA
C                 PRIOR TO DRAWING.                                          MA
C      YL     -   Y COORDINATE OF LAST PEN POSITION                          MA
C      YMAX       COMMON VARIABLE                                            MA
C      Z(51,81)   STORAGE LOCATION FOR ELEVATION INFORMATION                 MA
C      ZMAX       COMMON VARIABLE                                            MA
C      ZMAX -     HIGHEST ELEVATION IN Z MATRIX                              MA
C      ZMIN -     LOWEST ELEVATION IN Z MATRIX                               MA
C      ZR         A COMPUTED RATIO USED IN INTERPOLATION                     MA
C                                                                            MA
C                                                                            MA
C                                                                            MA
C                                                                            MA
C*******VALUES ASSIGNED TO VARIABLE ADDRESSES******                          MA
C                                                                            MA
C          DURING THE SEARCH PROCEDURE, ITYP IS ASSIGNED                     MA
C          THE FOLLOWING VALUES AT THE DESIGNATED TIMES:                     MA
C          380-WHEN THE PROGRAM IS SEARCHING A COLUMN FROM BOTTOM TO         MA
C              TOP ( AT THE START OR WHEN SEARCHING THE INTERIOR             MA
C              OF THE Z MATRIX ).                                            MA
C          480-WHEN THE PROGRAM IS SEARCHING A ROW FROM                      MA
C              LEFT TO RIGHT ( ARROW 2 IN THE SEARCH                         MA
C              DIAGRAM IN THE DOCUMENTATION ).                               MA
C          455-WHEN THE PROGRAM IS SEARCHING A COLUMN FROM                   MA
C              TOP TO BOTTOM ( ARROW 3 IN SEARCH DIAGRAM                     MA
C              IN THE DOCUMENTATION ).                                       MA
C          410-WHEN THE PROGRAM IS SEARCHING A ROW FROM                      MA
C              RIGHT TO LEFT ( ARROW 4 IN THE SEARCH DIAGRAM                 MA
C              IN THE DOCUMENTATION ).                                       MA
C          DURING THE SEARCH PROCEDURE, NETAV IS ASSIGNED                    MA
C          THE FOLLOWING VALUES AT THE TIMES DESIGNATED:                     MA
C          380-WHEN THE PROGRAM IS SEARCHING THE BORDER                      MA
C              OF THE Z MATRIX.                                              MA
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C         385-WHEN THE PROGRAM IS SEARCHING THE INTERIOR
C              OF THE Z MATRIX.
C         DURING THE SEARCH PROCEDURE, NETAH IS ASSIGNED
C         THE FOLLOWING VALUES AT THE TIMES DESIGNATED:
C         410-WHEN THE PROGRAM IS SEARCHING THE BORDER
C              OF THE Z MATRIX.
C         415-WHEN THE PROGRAM IS SEARCHING THE INTERIOR
C              OF THE Z MATRIX.
C         DURING THE SEARCH PROCEDURE, NETBV IS ASSIGNED
C         THE FOLLOWING VALUES AT THE TIMES DESIGNATED:
C         455-WHEN THE PROGRAM IS SEARCHING THE BORDER
C              OF THE Z MATRIX.
C         460-WHEN THE PROGRAM IS SEARCHING THE INTERIOR
C              OF THE Z MATRIX.
C         DURING THE SEARCH PROCEDURE, NETBH IS ASSIGNED
C         THE FOLLOWING VALUES AT THE TIMES DESIGNATED:
C         480-WHEN THE PROGRAM IS SEARCHUNG THE BORDER
C              OF THE Z MATRIX.
C         485-WHEN THE PROGRAM IS SEARCHING THE INTERIOR
C              OF THE Z MATRIX.
C         DURING THE SEARCH PROCEDURE, LSRET IS ASSIGNED
C         THE FOLLOWING VALUES AT THE TIMES DESIGNATED:
C         220-WHEN THE PROGRAM IS SEARCHING A BORDER
C              COLUMN FROM BOTTOM TO TOP ( ARROW 1 IN THE
C              SEARCH DIAGRAM IN THE DOCUMENTATION ).
C         240-WHEN THE PROGRAM IS SEARCHING A ROW FROM LEFT
C              TO RIGHT ( ARROW 2 IN THE SEARCH DIAGRAM
C              IN THE DOCUMENTATION ).
C         260-WHEN THE PROGRAM IS SEARCHING A COLUMN FROM
C              TOP TO BOTTOM ( ARROW 3 IN THE SEARCH DIAGRAM
C              IN THE DOCUMENTATION ).
C         280-WHEN THE PROGRAM IS SEARCHING A ROW FROM
C              RIGHT TO LEFT ( ARROW 4 IN THE SEARCH DIAGRAM
C              IN THE DOCUMENTATION ).
C         305-WHEN THE PROGRAM IS SEARCHING THE INTERIOR
C              OF THE Z MATRIX.
C         DURING THE DETERMINATION OF THE TRACE OF A CONTOUR
C         LINE ( AS THE XC AND YC VECTORS ARE BEING FILLED ),
C        LDRET IS ASSIGNED THE FOLLOWING VALUES AT THE
C         TIMES DESIGNATED:
C         395-WHEN THE CONTOUR LINE ENTERS A TYPE A TRIANGLE
C              ON THE VERTICAL SIDE ( AN ARROW TANGENT
C              TO THE CONTOUR LINE IS HORIZONTAL, POINTING
C              TO THE RIGHT ).
C         420-WHEN THE CONTOUR LINE ENTERS A TYPE A TRIANGLE
C              ON THE HORIZONTAL SIDE ( AN ARROW TANGENT
C              TO THE CONTOUR LINE IS VERTICAL, POINTING UP ).
C         440-WHEN THE CONTOUR LINE ENTERS A TYPE A TRIANGLE
C              ON THE DIAGONAL ( AN ARROW TANGENT TO THE
C              CONTOUR LINE IS POINTING TO THE LOWER LEFT ).
C         465-WHEN THE CONTOUR LINE ENTERS A TYPE B TRIANGLE
C              ON THE VERTICAL SIDE ( AN ARROW TANGENT TO
C              THE CONTOUR LINE IS HORIZONTAL, POINTING TO THE LEFT ).
C         490-WHEN THE CONTOUR LINE ENTERS A TYPE B TRIANGLE
C              ON THE HORIZONTAL SIDE ( AN ARROW TANGENT
C              TO THE CONTOUR LINE IS VERTICAL, POINTING
C              DOWN ).
C         510-WHEN THE CONTOUR LINE ENTERS A TYPE B TRIANGLE
C              ON THE DIAGONAL ( AN ARROW TANGENT TO THE
C              CONTOUR LINE IS POINTING TO THE UPPER RIGHT ).
C
C
C**********************
C
C
C    JOHN M. SNOWDEN          JULY 1969
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C     THE OHIO STATE UNIVERSITY                                                  MA
C     INSTRUCTION AND RESEARCH COMPUTER CENTER                                  MA
C     1971 NEIL AVENUE                        (614-422-6333)                    MA
C     COLUMBUS, OHIO 43210                                                      MA
C                                                                               MA
C                                                                               MA
C        UPDATED        NOVEMBER 1972                                           MA
C        U. S. ARMY COMBAT DEVELOPMENTS COMMAND                                 MA
C        SYSTEMS ANALYSIS GROUP                                                 MA
C        FORT BELVOIR, VA 22060                                                 MA
C                                                                               MA
C                                                                               MA
C********************************************************************MAIN ENTRY MA
C//////////////////////////////////////////////////////////////////////////////  MA
      DIMENSION X(21100),Y(21100),Z(21100),XC(100),YC(100),IBUF(1000),        HL
     *I30(3)                                                                    HL
C//////////////////////////////////////////////////////////////////////////////  MA
      EQUIVALENCE (X,XX), (Y,YY), (Z,ZZ)                                        MA
C     THIS CARD READS THE SCALE FACTIR AND X                                    MA
C EX SCALE =.00156 INCHES TO ONE METER AND X                                    MA
      READ (1,1) SCALE,XL,YL                                                    MA
      READ(1,7) E,NC,NR,CNTRVL,I30                                              HL
    7 FORMAT(F4.1,2I4,F5.1,3A10)                                                HL
      PRINT 9,E,NC,NR,CNTRVL,I30                                                CO
    9 FORMAT(1X,F5.1,2I4,F6.1,3A10)                                             CC
      NUMZ = NC * NR                                                            HL
      DO 8 IZ = 1, NUMZ                                                         HL
      READ(10,8453) M                                                           HL
      Z(IZ) = M                                                                 HL
 8453 FORMAT (I5)                                                               HL
    8 CONTINUE                                                                  HL
      CALL PLOTS (IBUF,1000,2)                                                  HL
    1 FORMAT (F8.7,2F6.0)                                                       MA
      XD=XL*SCALE                                                               MA
      YD=YL*SCALE                                                               MA
      CALL PLOT (0.0,2.0,-3)                                                    HL
      CALL PLOT (XD,0.0,2)                                                      MA
      CALL PLOT (XD,YD,2)                                                       MA
      CALL PLOT (0.0,YD,2)                                                      MA
      CALL PLOT (0.0,0.0,2)                                                     MA
      II=XL/1000.+1.                                                            MA
      JJ=YL/1000.+1.                                                            MA
      XDD=XD+.1                                                                 MA
      YDD=YD+.1                                                                 MA
      DO 2 I=1,II                                                               MA
      J=I-1                                                                     MA
      ENCODE (10,3,L) J                                                         MA
    3 FORMAT (I2)                                                               MA
      XI=J*SCALE*1000.                                                          M
      CALL SYMBOL (XI,-.5,.21,L,0.0,2)                                          M
      CALL SYMBOL (XI,YDD,.21,L,0.0,2)                                          M
    2 CONTINUE                                                                  M
      DO 4 I=1,JJ                                                               M
      J=I-1                                                                     M
      ENCODE (10,3,L) J                                                         M
      YI=J*SCALE*1000.                                                          M
      CALL SYMBOL (-.55,YI,.21,L,0.0,2)                                         M
      CALL SYMBOL (XDD,YI,.21,L,0.0,2)                                          M
    4 CONTINUE                                                                  M
      II=II-2                                                                   M
      JJ=JJ-2                                                                   M
      CALL SYMBOL(2.,-1.4,.42,I30,0.,30)                                        H
      DO 5 I=1,JJ                                                               M
      D=I*SCALE*1000.                                                           M
      CALL PLOT (0.0,D,3)                                                       M
      CALL PLOT (XD,D,2)                                                        M
```

```
    5 CONTINUE
      DO 6 I=1,TI
      D=I*SCALE*1000.
      CALL PLOT (D,0.0,3)
      CALL PLOT (D,YD,2)
    6 CONTINUE
60    CONTINUE
C
C     DX IN THIS DO LOOP IN THE INCREASE IN THE
C     X COORDINATE BETWEEN SUCCESSIVE COLUMNS
C     IN THE ELEVATION MATRIX.  DX IS RELATED
C     TO THE NUMBER OF COLUMNS IN THE X,Y,AND
C     Z MATRICES AND THE LENGTH OF THE X AXIS
C     BY THE EQUALITY: DX*(NC-1)=LENGTH OF AXIS.
C     THE ACTUAL GROUND DISTANCE REPRESENTED
C     BY DX IS EQUAL TO DX*LAST PARAMETER IN
C     AXIS CALL.  X IS INITIALIZED SUCH THAT
C     X(I,J)=DX*(J-1).  DY IS THE INCREASE IN
C     THE Y COORDINATE BETWEEN SUCCESSIVE ROWS
C     IN THE ELEVATION MATRIX.  THE RELATION:
C     DY*(NR-1)=LENGTH OF Y AXIS MUST HOLD.
C     THE GROUND DISTANCE REPRESENTED BY DY=
C     DY*LAST PARAMETER IN Y AXIS CALL.  AFTER
C     BEING INITIALIZED, Y(I,J)=DY*(I-1).
C
      DX=0.0
C/////////////////////////////////////////////////////////////////////
      DO 40 J=1,NC
C/////////////////////////////////////////////////////////////////////
       DY=0.0
C/////////////////////////////////////////////////////////////////////
      DO 30 I=1,NR
C/////////////////////////////////////////////////////////////////////
      IJ = (J-1) *NR + I
      X(IJ) = DX
      Y(IJ) = DY
C/////////////////////////////////////////////////////////////////////
      DY=DY+SCALE*E
C/////////////////////////////////////////////////////////////////////
   30 CONTINUE
C/////////////////////////////////////////////////////////////////////
      DX=DX+SCALE*E
C/////////////////////////////////////////////////////////////////////
   40 CONTINUE
      CALL PLOT(0.0,0.0,3)
C/////////////////////////////////////////////////////////////////////
      LC=100
      NL=5
      LCS=100
      WTCP=2.0
      DYL=.17
      NLC=5
      NDL=-1
      HCL=.07
      SL=30.
      KSW=1
      XL=0.0
      YL=0.0
C/////////////////////////////////////////////////////////////////////
      DATA BIAS/5.0/,LC/100/,DTEL/0.75/
C   IF THIS ENTRY IS NOT CALLED PRIOR TO CALLING CGTOUR, THE PARAMETERS
C      DEFAULT TO VALUES WHICH WILL PRODUCE RESLUTS COMPATIBLE WITH
C      THE PREVIOUS VERSION OF CGTOUR (NO LABELS OR SMOOTHING)
C*********************************************************************
C     IT IS IMPORTANT THE DLTA BE SMALL COMPARED
C     TO CNTRVL.  WHEN AN ELEVATION IS EXACTLY EQUAL
```

```
C      TO A DECISION VARIABLE, DLTA IS ADDED TO THE
C      ELEVATION. IT IS NECESSARY TO KEEP THE ERROR
C      INVOLVED IN THIS PROCESS AS SMALL AS POSSIBLE.
C      THE VALUE 0.01 IS ARBITARY.
C
110    DLTA=CNTRVL*0.01
       WAVE=1.0/(WTCP+2.0)
C
C   COMPUTE ADDRESSING CONSTANTS
C
       KPD=2
       NX=NR
       NY=NC
       LGTH=NX*NY
       NX3=NX-3
       KSN=NY*(NY-1)
       KSNP1=KSN+1
C
C   FIND MINIMUM AND MAXIMUM Z VALUES
C
       ZMIN=Z(1)
       ZMAX=Z(1)
C
C      NOTE THAT WHEN BIAS IS ADDED TO X AND Y, BOTH VECTORS
C      BECOME STRICTLY POSITIVE.
C
       X(1)=X(1)+BIAS
       Y(1)=Y(1)+BIAS
   111 DO 135 I=2,LGTH
       X(I)=X(I)+BIAS
       Y(I)=Y(I)+BIAS
       IF (ZMIN-Z(I)) 125,135,120
120    ZMIN=Z(I)
       GO TO 135
125    IF (ZMAX-Z(I)) 130,135,135
130    ZMAX=Z(I)
135    CONTINUE
C
C      KCNMAX IS THE NUMBER OF CONTOUR LINES BETWEEN ZERO AND
C      ZMAX.  THIS VALUE WILL BE USED AS A_DECISION VARIABLE
C      TO TERMINATE THIS SURROUTINE.
C
       KCNMAX=IFIX(ZMAX/CNTRVL)
C
C      KCNT IS THE NUMBER OF CONTOUR LINES BETWEEN ZERO
C      AND ZMIN.  THIS VALUE WILL BE USED TO KEEP TRACK
C      OF THE NUMBER OF CONTOUR LINES DRAWN.  NOTE THAT BOTH
C      KCNT AND KCNMAX MAY BE NEGATIVE.
C
       PRINT 137,ZMAX,ZMIN
137    FORMAT (1X,2F5.0,13HZMAX AND ZMIN)
       KCNT=IFIX(ZMIN/CNTRVL)
       IF (ZMIN.GT.0.0) KCNT=KCNT+1
   136 CNT=FLOAT(KCNT)*CNTRVL
C
C   CHECK FOR NO CONTOURS
C
       IF (KCNMAX-KCNT) 140,145,145
   140 PRINT 141
   141 FORMAT (1X,57H ERROR.  CALCULATIONS SHOW THAT KCNMAX IS LESS THAN
      *KCNT.)
       GO TO 206
145    KEMP=KCNT-(KCNT/NL)*NL
C
C      NOTE THAT A VALUE FOR A VARIABLE IN CGTLAB MUST BE
C      AVAILABLE FOR THIS CALCULATION. NL.NE.NLC ONLY IF NO
```

```
C     LABELING IS DESIRED.
C
      IF(NL.NE.NLC) GO TO 205
      IF (KEMP) 205,150,205
C
C   CHECK FOR LABEL REQUEST
C
150   IF (NDL+1) 155,165,170
C*************************************************************************LABEL SETUP
155   NTCL=1
      NACL=NDL
      FLAB=CNT
160   FLAB=FLAB*0.1
      NACL=NACL+1
      IF (NACL+1) 160,180,180
165   NTCL=1
      GO TO 175
170   NTCL=NDL+2
175   NACL=NDL
      FLAB=CNT
180   TLAB=ABS(FLAB)
      NTCLX=NTCL
      DO 185 NTCL=NTCLX,32767
      IF (TLAB-10.) 190,185,185
185   TLAB=TLAB*0.1
190   IF (FLAB) 195,200,200
195   NTCL=NTCL+1
C
C   LABEL SPACE IN X DIRECTION
C
200   DXL=FLOAT(NTCL)*HCL+0.10
C*********************************************************CONTOUR BEGINNING SCAN
205   ASSIGN 380 TO NETAV
      ASSIGN 410 TO NETAH
      ASSIGN 455 TO NETBV
      ASSIGN 480 TO NETBH
C
C   SCAN COLUMN 1 EDGE, TYPE A TRIANGLE, VERTICAL SIDE
C     THE PROGRAM IS SEARCHING THE LEFT HAND BORDER.
C
      ASSIGN 220 TO LSRET
      ASSIGN 380 TO ITYP
      KS=1
C
C     BOTH X AND Y MATRICES WERE MADE STRICTLY
C     POSITIVE BY THE ADDITION OF BIAS.   AN X
C     ELEMENT CAN BE NEGATIVE ONLY IF THE
C     PROGRAM HAS MADE IT NEGATIVE TO INDICATE
C     THAT A CONTOUR LINE BEING DRAWN HAS
C     ALREADY PASSED THROUGH THAT SQUARE.
C     THIS TYPE OF TEST IS PERFORMED AT SEVERAL
C     POINTS IN THE PROGRAM.
C
210   IF (X(KS)) 220,215,215
215   LZ1=KS
      LZ2=KS+1
      GO TO 335
220   KS=KS+1
  221 IF (KS-NX) 210,225,225
C
C   SCAN ROW NX EDGE, TYPE B TRIANGLE, HORIZONTAL SIDE
C     THE PROGRAM IS SEARCHING THE TOP BORDER.
C
225   ASSIGN 240 TO LSRET
      ASSIGN 480 TO ITYP
230   IF (Y(KS)) 240,235,235
```

```
  235   LZ1=KS
        LZ2=KS+NX
        GO TO 335
  240   KS=KS+NX
        IF (KS-LGTH) 230,245,245
C
C     SCAN COLUMN NY EDGE, TYPE B TRIANGLE, VERTICAL SIDE
C       THE PROGRAM IS SEARCHING THE RIGHT HAND BORDER.
C
  245   ASSIGN 260 TO LSRET
        ASSIGN 455 TO ITYP
  250   KS1=KS-NX
        IF (Y(KS1)) 260,255,255
  255   LZ1=KS-1
        LZ2=KS
        GO TO 335
  260   KS=KS-1
        IF (KS-KSNP1) 265,265,250
C
C       SCAN ROW 1 EDGE, TYPE A TRIANGLE, HORIZONTAL SIDE
C       THE PROGRAM IS SEARCHING THE BOTTOM BORDER.
C
  265   ASSIGN 280 TO LSRET
        ASSIGN 410 TO ITYP
  270   LZ1=KS-NX
        IF (X(LZ1)) 280,275,275
  275   LZ2=KS
        GO TO 335
  280   KS=KS-NX
        IF (KS-1) 285,285,270
C
C     SCAN INTERIOR REGION, TYPE A TRIANGLE, VERTICAL SIDE
C       THE PROGRAM WILL NOW SEARCH THE COLUMNS FROM
C       BOTTOM TO TOP AND FROM LEFT TO RIGHT.
C
  285   ASSIGN 385 TO NETAV
        ASSIGN 415 TO NETAH
        ASSIGN 460 TO NETBV
        ASSIGN 485 TO NETBH
        ASSIGN 305 TO LSRET
        ASSIGN 380 TO ITYP
        KS=NX+2
  290   KSX=KS+NX3
  295   IF (X(KS)) 305,300,300
  300   LZ1=KS
        LZ2=KS+1
        GO TO 335
  305   KS=KS+1
        IF (KS-KSX) 295,310,310
  310   KS=KSX+3
        IF (KS-KSN) 290,290,315
C
C     CONTOUR COMPLETE, RESET CONTOUR TRACE FLAGS
C
  315   DO 320 I=1,LGTH
        X(I)=ABS(X(I))
  320   Y(I)=ABS(Y(I))
C
C       CHECK FOR NEXT CONTOUR
C
        CNT=CNT+CNTRVL
    321 KCNT=KCNT+1
    322 IF (KCNT-KCNMAX) 145,145,325
C
C     RESTORE INPUT X AND Y ARRAYS BEFORE RETURN
C
```

```
 325    DO 330 I=1,LGTH
        X(I)=X(I)-BIAS
 330    Y(I)=Y(I)-BIAS
        GO TO 206
C*****************************************************INITAL CROSSING SCAN
C       INITIAL CROSSING SCAN
C       COMPARES ELEVATION AT LZ1 TO THAT AT LZ2 AND
C       ASSIGNS INDEX OF LZH TO THE HIGHER, LZL TO
C       THE LOWER.
C
 335    IF (Z(LZ1)-Z(LZ2)) 350,340,345
 340    Z(LZ1)=Z(LZ1)+DLTA
        GO TO 335
 345    LZH=LZ1
        LZL=LZ2
        GO TO 355
 350    LZL=LZ1
        LZH=LZ2
C
C       COMPARES HIGHER ELEVATION TO CONTOUR LINE BEING
C       DRAWY. IF HIGHER ELEVATION IS LESS THAN THE
C       CONTOUR LINE BEING DRAWN, THE PROGRAM GOES TO
C       THE NEXT POINT.
C
 355    IF (CNT-Z(LZH)) 370,360,365
 360    Z(LZH)=Z(LZH)+DLTA
        GO TO 355
 365    GO TO LSRET, (220,240,260,280,305)
C
C
C       COMPARES LOWER ELEVATION TO CONTOUR LINE BEING
C       DRAWN. IF LOWER ELEVATION IS GREATER THAN CONTOUR
C       LINE BEING DRAWN, THE PROGRAM GOES TO THE NEXT
C       POINT. IF LOWER ELEVATION IS LESS, THE PROGRAM
C       STARTS TO TRACE A CONTOUR LINE.
C
 370    IF (Z(LZL)-CNT) 525,375,365
 375    Z(LZL)=Z(LZL)+DLTA
        GO TO 370
C*******************************************                 CONTOUR TRACING
C   ENTER TRIANGLE TYPE A ON VERTICAL SIDE
C
 380    IF (LZ1-KSN) 390,560,560
 385    IF (X(LZ1)) 565,390,390
C
C       LZ3 BECOMES THE POINT TO THE RIGHT OF LZ1.
C       THAT@S WHY KSN IS USED TO TERMINATE THE
C       PROCESS IN LINE 380.  IF LGTH WERE USED, THERE
C       WOULDN@T BE A POINT TO THE RIGHT OF LZ1.
C
 390    LZ3=LZ1+NX
        ASSIGN 335 TO LPRET
        GO TO 530
C
C       THE PROGRAM IS INDICATING THAT THE
C       CONTOUR LINE HAS PASSED THROUGH A
C       PARTICULAR SQUARE.  THIS FLAG WILL BE
C       USED TO TERMINATE THE TRACE OF A CONTOUR
C       LINE IF IT CLOSES ON ITSELF.  BOTH X AND
C       Y VALUES ARE MARKED THIS WAY AT SEVERAL
C       POINTS IN THE PROGRAM.
C
 395    X(LZ1)=-X(LZ1)
        IF (LZ4-LZ1) 400,405,400
 400    LZ1=LZ2
        LZ2=LZ3
```

```
      GO TO 505
405   LZ2=LZ3
      GO TO NETBH, (480,485)
C
C     ENTER TRIANGLE TYPE A ON HORIZONTAL SIDE
C       TESTS TO SEE IF YOU HAVE COMPLETED A COLUMN.
C       MOD(LZ1,NX)=0 IF THE ANSWER IS YES.
C
410   IF (MOD(LZ1,NX)) 415,560,415
415   LZ3=LZ1+1
      ASSIGN 420 TO LDRET
      GO TO 530
420   X(LZ1)=-X(LZ1)
      IF (LZ4-LZ1) 430,425,430
425   LZ2=LZ3
      GO TO NETBV, (455,460)
430   LZ1=LZ3
      GO TO 505
C
C     ENTER TRIANGLE TYPE A ON DIAGONAL SIDE
C
435   LZ3=LZ1-1
      ASSIGN 440 TO LDRET
      GO TO 530
440   X(LZ3)=-X( LZ3)
      IF (LZ4-LZ1) 450,445,450
445   LZ2=LZ1
      LZ1=LZ3
      GO TO NETBV, (455,460)
450   LZ1=LZ3
      GO TO NETBH, (480,485)
C
C     ENTER TRIANGLE TYPE B ON VERTICAL SIDE
C
455   IF (LZ1-NX) 560,560,460
460   LZ3=LZ2-NX
      ASSIGN 465 TO LDRET
      GO TO 530
465   Y(LZ3)=-Y(LZ3)
      IF (LZ4-LZ1) 475,470,475
470   LZ2=LZ1
      LZ1=LZ3
      GO TO 435
475   LZ1=LZ3
      GO TO NETAH, (410,415)
C
C     ENTER TRIANGLE TYPE B ON HORIZONTAL SIDE
C
480   IF (MOD(LZ1,NX)-1) 485,560,485
485   LZ3=LZ2-1
      ASSIGN 490 TO LDRET
      GO TO 530
490   Y(LZ1)=-Y(LZ1)
      IF (LZ4-LZ1) 500,495,500
495   LZ2=LZ3
      GO TO 435
500   LZ1=LZ3
      GO TO NETAV, (380,385)
C
C       ENTER TRIANGLE TYPE B ON DIAGONAL SIDE
C
505     LZ3=LZ2+1
        ASSIGN 510 TO LDRET
        GO TO 530
510     Y(LZ1)=-Y(LZ1)
        IF (LZ4-LZ1) 520,515,520
```

```
515   LZ2=LZ3
      GO TO NETAH, (410,415)
520   LZ1=LZ2
      LZ2=LZ3
      GO TO NETAV, (380,385)
C*************************************************CONTOUR INTERPOLATING
C   CONTOUR BEGINNING INTERPOLATION
C     THE INTERPOLATION IS BASED ON THE ASSUMPTION
C     OF A LINER RELATIONSHIP BETWEEN X AND Z AND
C     Y AND Z.  ZR IS THE RATIO OF THE DIFFERENCE
C     IN ELEVATION BETWEEN LZH AND CNT AND LZL AND
C     LZH.  THIS RATIO IS USED TO ADJUST THE
C     COORDINATES OF LZH TO REPRESENT THE COORDINATES
C     OF THE CONTOUR LINE.
C
525   ZR=(CNT-Z(LZH))/(Z(LZL)-Z(LZH))
C
C     REMEMBER THAT BIAS WAS ADDED TO ALL X AND Y
C     ELEMENTS.  THIS MUST BE SUBTRACTED TO GET A
C     CORRECT VALUE FOR THE CONTOUR COORDINATES.
C
      XC(1)=ABS(X(LZH))+(ABS(X(LZL))-ABS(X(LZH)))*ZR-BIAS
      YC(1)=ABS(Y(LZH))+(ABS(Y(LZL))-ABS(Y(LZH)))*ZR-BIAS
      LCSS=1
      NCSF=0
      NCON=0
      GO TO ITYP, (380,480,455,410)
C
C   CONTOUR TRACE INTERPOLATING
C
530   IF (Z(LZ3)-CNT) 540,535,545
535   Z(LZ3)=Z(LZ3)+DLTA
      GO TO 530
540    LZ4=LZH
      LZL=LZ3
      GO TO 550
545   LZ4=LZL
      LZH=LZ3
550   LCSS=LCSS+1
      ZR=(CNT-Z(LZ3))/(Z(LZ4)-Z(LZ3))
      XC(LCSS)=ABS(X(LZ3))+(ABS(X(LZ4))-ABS(X(LZ3)))*ZR-BIAS
      YC(LCSS)=ABS(Y(LZ3))+(ABS(Y(LZ4))-ABS(Y(LZ3)))*ZR-BIAS
      IF (LCSS-LC) 555,570,570
555   GO TO LDRET, (395,420,440,465,490,510)
C************************************************** CONTOUR TERMINATING
C   CONTOUR TERMINATES ON EDGE OF GRID
C
560   NENTY=-1
      GO TO 575
C
C     CONTOUR TERMINATES AT CONTOUR BEGINNING
C
565   NENTY=NCSF
      GO TO 575
C
C   CONTOUR COORDINATE SAVE STRINGS FULL
C
570   NENTY=1
      NCSF=-1
575   IF (LCSS-LCS) 590,590,580
C
C     COORDINATE SMOOTHING
C
580   DO 585 I=3,LCSS
      XC(I-1)=(XC(I-2)+WTCP*XC(I-1)+XC(I))*WAVE
585   YC(I-1)=(YC(I-2)+WTCP*YC(I-1)+YC(I))*WAVE
```

```
590   IF (NENTY) 605,595,600
C
C   CLOSED LOOP, SMOOTH POINT OF CLOSURE
C
595   XC(1)=(XC(LCSS-1)+WTCP*XC(1)+XC(2))*WAVE
      YC(1)=(YC(LCSS-1)+WTCP*YC(1)+YC(2))*WAVE
      XC(LCSS)=XC(1)
      YC(LCSS)=YC(1)
      GO TO 610
C
C     COORDINATE SAVE STRINGS FULL
600   LCSS=LCSS-1
      GO TO 610
C
C     TERMINATED ON EDGE OF GRID, FIND END NEAREST LAST PEN POSITION
C
605   DB=(XC(1)-XL)**2+(YC(1)-YL)**2
      DE=(XC(LCSS)-XL)**2+(YC(LCSS)-YL)**2
      IF (DB-DE) 610,610,615
C
C     PEN IS CLOSER TO START OF CONTOUR LINE.  START
C     AT XC(1),YC(1) AND GO TO XC(LCSS),YC(LCSS).
C
610   I=1
      K=LCSS
      INC=1
      GO TO 620
C
C     PEN IS CLOSER TO END OF CONTOUR LINE.  START
C     AT XC(LCSS),YC(LCSS) AND GO TO YC(1),YC(1)
C
615   I=LCSS
      K=1
      INC=-1
C*******************************************************CONTOUR PLOTTING
C     BEGINNING OF PLOTTING
C
620   CALL PLOT (XC(I),YC(I),3)
C
C     IF KEMP=0, A LABEL IS REQUIRED FOR THIS CONTOUR
C     LINE.
C
  621 IF (KEMP) 625,630,625
C
C   UNLABELED CONTOUR
C
625   I=I+INC
      CALL PLOT (XC(I),YC(I),KPD)
      IF (I-K) 625,710,625
C
C    LABELED CONTOUR
C
630   IF (NCON) 695,635,695
635   XL=XC(I)
      YL=YC(I)
640   I=I+INC
      CALL PLOT (XC(I),YC(I),KPD)
      IF (I-K) 645,710,645
C
C     THE PROGRAM IS CHECKING TO SEE IF THE PEN IS
C     FAR ENOUGH AWAY FROM THE EDGE TO WRITE A
C     LABEL.  IF NOT, IT WILL DRAW ANOTHER SEGMENT
C     AND TEST AGAIN.
C
645   IF ((XC(I)-XL)**2+(YC(I)-YL)**2-DTFL) 640,650,650
C
```

```
C     LABEL SPACE SCAN
C
650      XL=XC(I)
         YL=YC(I)
         NCON=I
655      I=I+INC
         IF (I-K) 660,685,660
660      DE=XC(I)-XL
         DB=YC(I)-YL
         IF (ABS(DE)-ABS(DB)) 675,675,665
C
C    LABEL SPACE GREATER IN X DIRECTION
665      IF (ABS(DE)-DXL) 655,670,670
C
C     LABEL SPACE AVAILABLE IN X DIRECTION
C
670      DE=XL+SIGN(DXL,DE)
         J=I-INC
         DB=(DE-XC(I))/(XC(J)-XC(I))*(YC(J)-YC(I))+YC(I)
         GO TO 690
C
C        LABEL SPACE SCAN IN Y DIRECTION
C
675      IF (ABS(DB)-DYL) 655,680,680
C
C        LABEL SPACE AVAILABLE IN Y DIRECTION
C
680      DB=YL+SIGN(DYL,DB)
         J=I-INC
         DE=(DB-YC(I))/(YC(J)-YC(I))*(XC(J)-XC(I))+XC(I)
         GO TO 690
C
C        PLOTTING TERMINATED DURING LABEL SPACE SCAN
C
685      I=NCON
         NCON=0
         GO TO 625
C
C        LOCATE LOWER LEFT CORNER OF LABEL
C
690      XL=(XL+DE-DXL+0.10)*0.5
         YL=(YL+DB-DYL+0.10)*0.5
         CALL NUMBER (XL,YL,HCL,FLAB,0.0,NACL)
         CALL PLOT (DE,DB,3)
         NCON=I
         GO TO 700
C
C     CONTOUR PLOTTING RESUMED AFTER LABEL
C
695      I=I+INC
700      CALL PLOT (XC(I),YC(I),KPD)
         IF (I-K) 705,710,705
705      IF (ABS(XC(I)-XL)+ABS(YC(I)-YL)-SL) 695,650,650
C********************************************CONTOUR PLOTTING TERMINATION
C     TERMINATING AT EDGE OF GRID
C
710      XL=XC(I)
         YL=YC(I)
         IF (NENTY) 715,715,720
C
C     TERMINATING ON SELF
C
715      GO TO LSREI, (220,240,260,280,305)
C
C     COORDINATE SAVE STRINGS FULL
C
```

```
720   XC(1)=XC(LCSS)
      YC(1)=YC(LCSS)
      XC(2)=XC(LCSS+1)
      YC(2)=YC(LCSS+1)
      LCSS=2
      GO TO LDRET, (395,420,440,465,490,510)
206   XXXX=XD+4.
      CALL RTE(SCALE)
      REWIND 31
      CALL RTE(SCALE)
11300 CALL SYMBOL (XXXX,0.0,.42,11HEND OF PLOT,0.0,11)
      CALL PLOT (0.0,0.0,999)
      END FILE 2
   50 STOP
      END
      SUBROUTINE RTE(SCALE)
      DIMENSION IX(5),IY(5),X(5),Y(5)
    2 READ (31,10) ID,NO
      IF (EOF(31)) 999,1,999
    1 IF (ID.EQ.2HIU) GO TO 40
      IF(ID.NE.2HRT) GO TO 2
      BACKSPACE 31
      READ(31,10) ID,NO,(IX(I),IY(I),I=1,5)
   10 FORMAT(A2,A1,5X,2I3,4(7X,2I3))
      DO 4 I=1,5
      X(I) = IX(I)*10*SCALE
    4 Y(I) = IY(I)*10*SCALE
      IF(NO.NE.1H1) GO TO 3
      CALL PLOT (X(1),Y(1),3)
      GO TO 99
    3 CALL PLOT (X(1),Y(1),2)
   99 DO 98 I=2,5
   98 CALL PLOT(X(I),Y(I),2)
      GO TO 2
   40 CONTINUE
      BACKSPACE 31
      READ(31,42) (IX(I),IY(I),I=1,3)
   42 FORMAT(9X,6I3)
      DO 43 I=1,3
      X(I) = IX(I)*10*SCALE
      Y(I) = IY(I)*10*SCALE
   43 CALL SYMBOL(X(I),Y(I),.21,1HA,0.,1)
      GO TO 2
  999 RETURN
      END
50.00100008700200  HLT 90 SITE A
```

Inclosure A-I-e

Joining Partial Arrays from Two or More DMA Tapes (UATA5)

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UATA5,T500,MT3.  PROGRAM USED TO JOIN ARRAYS OF ELEV MATRICES
TASK,TN=TETAM,TA=18464,WP=01,OS=ATCACAM,TR=TS.
PAUSE. TAPE 3 AND TAPE 4 ARE THE TWO INPUT ELEVATION MATRICES
VSN,TAPE3=6947.   J9/4
LABEL,TAPE3,R,D=PE,L=J904.
VSN,TAPE4=6366.   J905
LABEL,TAPE4,R,D=PE,L=J905.
PAUSE. L=J9J6*J0B=UAT94 TRK=9 DEN=PE PI=HW TSK =IUAMNT OS=ATCACAM
PAUSE. TAPE 5 IS THE RESULTANT ELEVATION FILE (MERGED)
VSN,TAPE5=SAVE.  THIS IS A REQUEST FOR THE OUTPUT TO BE SAVED
LABEL,TAPE5,W,D=PE,L=J9J6.
FTN,L=0.
LGO.
      PROGRAM ARRAY (INPUT,OUTPUT,TAPE1=INPUT,TAPE2=OUTPUT,TAPE3,TAPE4,
     -TAPE5)
C
C     THIS PROGRAM WILL POSITION TWO ARRAYS TOGETHER TO GIVE ONE LARGE A
C     THE PURPOSE IS TO FIT TOGETHER TWO MAP ARRAYS OF ELEVATIONS.
C     WHEN FORMING THE LARGER COMPOSITE ARRAY,THE PROGRAM WILL FILL THE
C         NOT COVERED BY THE INPUT AREAS, WITH ZEROS.
C     THE PROGRAM WILL READ ONE INPUT CARD.
C   TAPE3 IS THE FIRST INPUT ARRAY
C    TAPE4 IS THE SECOND INPUT ARRAY
C    TAPE5 IS THE OUTPUT ARRAY AND WILL BE WRITTEN UNDER AN I5 FORMAT
C   WITH EACH VALUE VARYING THE Y FIRST THEN THE X
C  ONLY ONE INPUT CARD CONSISTING OF NINE FIELDS EACH FMT I3
C   THE VARIABLE FMT SHOULD BE SET TO 0 IF INPUT RECORDS ARE 16I5
C     SET FMT = 1 IF INPUT RECORD IS FORMATTED I5.
C     IN(1) = NUMBER OF ROWS IN FIRST ARRAY.
C     IN(2) = NUMBER OF COLUMNS IN FIRST ARRAY.
C     IN(3) = NUMBER OF ROWS IN SECOND ARRAY.
C     IN(4) = NUMBER OF COLUMNS IN SECOND ARRAY.
C     THE NEXT FOUR ENTRIES DESCRIBE THE X,Y COORDINATES OF THE SOUTH-WE
C         CORNER OF EACH ARRAY WITH RESPECT TO THE (1,1) COORDINATE.
C     HOW DO YOU KNOW WHERE THE (1,1) POINT IS&
C     WELL,AFTER LOOKING AT HOW THE TWO MAP ARRAYS FIT TOGETHER, THE WES
C         COLUMN WILL BE ON THE Y-AXIS    AND THE SOUTHMOST ROW WILL BE
C         X-AXIS.       THEN OBVIOUSLY WHERE THE X-AXIS CROSSES THE Y-AX
C         THE POINT (1,1).
C
C     IN(5) = X COORDINATE OF SOUTH-WEST CORNER OF FIRST ARRAY WITH RESP
C             TO (1,1) POINT.
C     IN(6) = Y COORDINATE OF SOUTH-WEST CORNER OF FIRST ARRAY WITH RESP
C             TO (1,1) POINT.
C     IN(7) = X COORDINATE OF SOUTH-WEST CORNER OF SECOND ARRAY WITH RES
C             TO (1,1) POINT.
C     IN(8) = Y COORDINATE OF SOUTH-WEST CORNER OF SECOND ARRAY WITH RES
C      TO (1,1) POINT.
C    THE LAST FIELD IFMT WILL BE A 0 IF THE INPUT ARRAYS WERE WRITTEN
C   BY A 16I5 FORMAT RECORD, A 1 IF WRITTEN BY A I5 FORMAT.
      DIMENSION IN(8),MAR(16),NAR(16)
    1 READ (1,2) (IN(I),I=1,8),IFMT
    2 FORMAT (9I3)
      IF (EOF(1)) 50,51
C
C     ISW IS A SWITCH USED TO ALLOW CODE FROM 41 THRU 9 TO BE USED TO
C         CALCULATE THE SIZE OF NEW ARRAY. ISW=0 WHEN CALCULATING NUMBER
C         OF ROWS AND ISW=1 WHEN CALCULATING NUMBER OF COLUMNS.
C
51    ISW=0
C
C     THIS IF STATEMENT WILL DETERMINE THE ARRAY WITH MOST COLUMNS.
```

```
C
      IF (IN(2).GT.IN(4)) GO TO 3
C
C     STATEMENTS 4 THRU 12 CALCULATE COMPOSITE ARRAY SIZE AND PRINT IT O
C
      I=4
      J=2
      K=7
      L=5
    4 IF (IN(L).EQ.1) GO TO 5
      IHLD=IN(L)+IN(J)-1
      IF (IHLD.GT.IN(I)) GO TO 7
      GO TO 6
    3 I=2
      J=4
      K=5
      L=7
      GO TO 4
    5 IF (IN(K).EQ.1) GO TO 6
      MX=IN(I)+IN(K)-1
      GO TO 9
    6 MX=IN(I)
      GO TO 9
    7 MX=IHLD
    9 IF(ISW.EQ.1) GO TO 11
      ISW=1
      MXA=MX
      IF (IN(1).GT.IN(3)) GO TO 10
      I=3
      J=1
      K=8
      L=6
      GO TO 4
   10 I=1
      J=3
      K=6
      L=8
      GO TO 4
   11 MYA=MX
      PRINT 12,MYA,MXA
   12 FORMAT (1X,30HDIMENSION OF COMPOSITE ARRAY (,I3,1H,,I3,2H).)
C
C     JAX1 IS SET TO 1 IF SCAN POINT IS WITHIN RANGE OF FIRST ARRAY COLU
C     JAY1 IS SET TO 1 IF SCAN POINT IS WITHIN RANGE OF FIRST ARRAY ROWS
C     JAX2 IS SET TO 1 IF SCAN POINT IS WITHIN RANGE OF SECOND ARRAYS CO
C     JAY2 IS SET TO 1 IF SCAN POINT IS WITHIN RANGE OF SECOND ARRAYS RO
C     THE ABOVE VARIABLES ARE SET TO 0 IF NOT IN RANGE.
C     IF BOTH THE JAX1 AND JAY1 ARE = 1 THEN ARRAY1 IS READ FROM TAPE3 A
C     WRITTEN TO ARRAY5.
C     IF BOTH THE JAX2 AND JAY2 ARE = 1 THEN ARRAY2 IS READ FROM TAPE4 A
C     WRITTEN TO TAPE5.
C     IF SCAN POINT IS NOT WITHIN ARRAY1 OR ARRAY2 THEN A 0 IS WRITTEN T
C     TAPE5.
C
C     THE SCAN POINT IS DEFINED BY THE DOUBLE DO LOOPS THAT SEQUENTIALLY
C     SCAN EACH COLUMN  FROM LEFT TO RIGHT UNTIL ALL COLUMNS HAVE BEEN S
C          IN THE COMPOSITE ARRAY.
C
C     TAPE3 AND TAPE4 MUST BE READ UNDER THE FORMAT 16I5 OR THE PROGRAM
C          CHANGED.
C
      JAX1=0
      JAX2=0
      DO 110 I=1,MXA
      ICNT=16
      JCNT=16
```

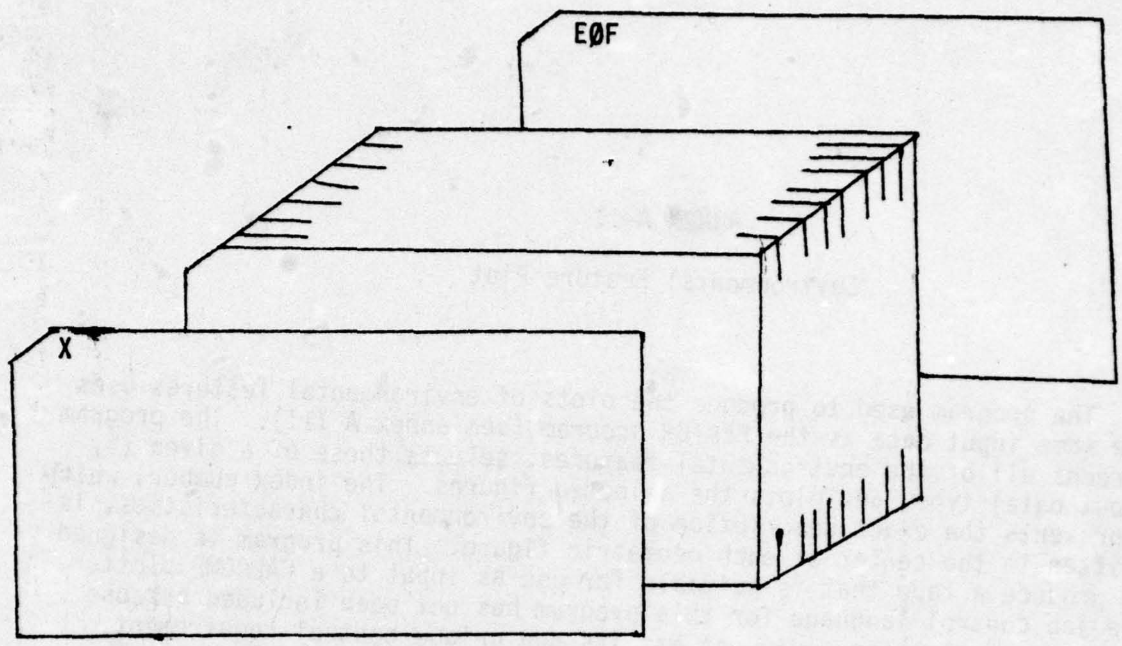
```
      IF (I.EQ.IN(5)) JAX1=1
      IF (I.GE.IN(5)+IN(2)) JAX1=0
      IF (I.EQ.IN(7)) JAX2=1
      IF (I.GE.IN(7)+IN(4)) JAX2=0
      JAY1=0
      JAY2=0
      DO 100 J=1,MYA
      IF (J.EQ.IN(6)) JAY1=1
      IF (J.GE.IN(6)+IN(1)) JAY1=0
      IF (J.EQ.IN(8)) JAY2=1
      IF (J.GE.IN(8)+IN(3)) JAY2=0
      IF (JAX1.EQ.1.AND.JAY1.EQ.1) GO TO 16
      IF (JAY2.EQ.1.AND.JAX2.EQ.1) GO TO 19
      IOUT=0
   14 WRITE (5,15) IOUT
   15 FORMAT (I5)
  100 CONTINUE
  110 CONTINUE
      STOP
   16 IF(IFMT.EQ.1) GO TO 25
      ICNT=ICNT+1
      IF (ICNT.GT.16) GO TO 17
      IOUT=MAR(ICNT)
      GO TO 14
   17 READ (3,18) (MAR(NUM),NUM=1,16)
   18 FORMAT (16I5)
      ICNT=0
      GO TO 16
   19 IF(IFMT.EQ.1) GO TO 27
      JCNT=JCNT+1
      IF(JCNT.GT.16) GO TO 20
      IOUT=NAR(JCNT)
      GO TO 14
   20 READ (4,21) (NAR(NUM),NUM=1,16)
   21 FORMAT (16I5)
      JCNT=0
      GO TO 19
   25 READ (3,26) IOUT
   26 FORMAT (I5)
      GO TO 14
   27 READ (4,26) IOUT
      GO TO 14
   50 STOP
      END
0941600601600010010010950001

***********              CMTXXDC   //// END OF LIST ////
***********              CMTXXDC   //// END OF LIST ////
```

ANNEX A-II

Environmental Feature Plot

The program used to produce the plots of environmental features uses the same input data as the FEATUR program (see annex A-III). The program screens all of the environmental features, selects those of a given (by input data) type, and plots the selected figures. The index number, which represents the exact description of the environmental characteristics, is written in the center of each geometric figure. This program is designed to produce a tape that is suitable for use as input to a CALCOMP plotter. The job control language for this program has not been included because each set of plotting equipment has its own unique control requirement. A schematic portrayal of the input deck is shown in figure A-II-1. The program is attached as inclosure A-II-a.



Card #	Card Column	Terrain Feature Type
1	1	1; Concealment, 2; Cover, 3; Trafficability, 4; Rough Terrain, 5; Minefields, 6; Smoke, 7; Not used, 8; All features.
2-N		Data cards used in the FEATUR program
N+1	1(1 and 2)	End of file (delimiter)

Figure A-II-1. Configuration of FEATUR Input Deck

Inclosure A-II-a

Environmental Feature Plot Program

```
      DIMENSION NUMBER(10)
      DIMENSION XVALS(20),YVALS(20),ITYPE(8)
      DIMENSION NUMBET(10)
      DATA NUMBET/"1","2","3","4","5","6","7","8","9","10"/
      DO 105 I=1,10
  105 NUMBER(I) = I
      S=.005
      IFIRST = 1
      READ(5,22) NOW
   22 FORMAT(I1)
      CALL PLOTS(IBUF,IDUM,14)
C   START OF GRID
      CALL PLOT(8.,2.6,-3)
      XVALS(1)=0.0
      XVALS(2)=15000.
      DO 11 I=1,4
      YVALS(I)=1000.*I
      CALL PLOT(S*XVALS(1),S*YVALS(I),3)
      CALL PLOT(S*XVALS(2),S*YVALS(I),2)
   11 CONTINUE
      YVALS(1)=0.0
      YVALS(2)=5000.
      DO 12 I=1,14
      XVALS(I)=1000.*I
      CALL PLOT(S*XVALS(I),S*YVALS(1),3)
      CALL PLOT(S*XVALS(I),S*YVALS(2),2)
   12 CONTINUE
      XVALS(1)=0.0
      XVALS(2)=0.0
      XVALS(3)=15000.
      XVALS(4)=15000.
      YVALS(1)=0.0
      YVALS(2)=5000.
      YVALS(3)=0.0
      YVALS(4)=5000.
      GO TO 5
    1 READ(5,9,END=2) (XVALS(I),YVALS(I),I=1,4),(ITYPE(J),J=1,8)
    9 FORMAT(8F6.0,8I3)
      IF( ITYPE(NOW) .EQ. 0 ) GO TO 1
      CALL SORT(XVALS,YVALS)
    5 CALL PLOT(S*XVALS(1),S*YVALS(1),3)
      CALL PLOT(S*XVALS(2),S*YVALS(2),2)
      CALL PLOT(S*XVALS(4),S*YVALS(4),2)
      CALL PLOT(S*XVALS(3),S*YVALS(3),2)
      CALL PLOT(S*XVALS(1),S*YVALS(1),2)
  102 IF(IFIRST.NE.1) GO TO 104
      YVALS(1) = 0.0
      CALL PLOT(S*XVALS(1),S*YVALS(1),-3)
      IFIRST = 2
      GO TO 1
  104 SUMX = 0.0
      SUMY = 0.0
      DO 100 I=1,4
      SUMX = SUMX + XVALS(I)
  100 SUMY = SUMY + YVALS(I)
      SUMX = SUMX / 4.0
      SUMY = SUMY / 4.0
      NCHAR = 1
      DO 101 I=1,10
      IF(ITYPE(NOW).NE.NUMBER(I)) GO TO 101
      IF(I.EQ.10) NCHAR = 2
      CALL SYMBOL(S*SUMX,S*SUMY,0.07,NUMBET(I),0,NCHAR)
      GO TO 1
```

```
      GO TO 1
  101 CONTINUE
    2 CONTINUE
      THO=0.0
      THF=360.0
      DI=0.0
    3 READ(8,7,END=6) XLOC,YLOC,RO,(ITYPE(J),J=1,8)
    7 FORMAT(3F6.0,8I3)
      IF( ITYPE(NOW) .EQ. 0 ) GO TO 3
      NCHAR = 1
      DO 103 I=1,10
      IF(ITYPE(NOW).NE.NUMBER(I)) GO TO 103
      IF(I.EQ.10) NCHAR = 2
      ZLOC = XLOC - RO
      CALL SYMBOL(S*ZLOC,S*YLOC,0.07,NUMBET(I),0,NCHAR)
      RF=RO
      CALL CIRCL(S*ZLOC,S*YLOC,THO,THF,S*RO,S*RF,DI)
      GO TO 3
  103 CONTINUE
    6 CALL PLOT(25.,0.,999)
      STOP
      END
      SUBROUTINE SORT(X,Y)
      DIMENSION X(1),Y(1)
      DO 3 K=1,2
      DO 2 J=1,3
      N=J+1
      DO 1 I=N,4
      IF(K.EQ.2.AND.(Y(J).LT.Y(I).OR.(X(J).LE.X(I).AND.Y(J).EQ.Y(I))))
     *   GO TO 1
      IF(K.EQ.1.AND.X(J).LE.X(I)) GO TO 1
      TEMPX=X(I)
      TEMPY=Y(I)
      X(I)=X(J)
      Y(I)=Y(J)
      X(J)=TEMPX
      Y(J)=TEMPY
    1 CONTINUE
    2 CONTINUE
    3 CONTINUE
      RETURN
      END
```

ANNEX A-III

FEATUR Program

The following information is provided for each geometric figure used in an environmental overlay:

1. Coordinate information (X and Y coordinates of each corner of a parallelogram or the X and Y coordinates of the center of a circle and the radius of the circle).

2. Index values for six terrain characteristics (concealment (vegetation), cover, trafficability (soil type), roughness, minefields, smoke in that order).

3. Knowledge of the figure (a code indicating who has knowledge of the environmental features represented by this figure).

0 neither side has knowledge
1 Blue side only has knowledge
2 Red side only has knowledge
3 both sides have knowledge

4. Number of the figure (for user reference only; this number has no program implications).

5. Special feature code (F for forest and M for minefield). This information is prepared in card format as indicated in figures A-III-1 and A-III-2. The FEATUR program provided has two situation-dependent subroutines included: XYCONV and XYCCNV. XYCONV with the appropriate origin and angle of rotation will convert UTM coordinates into DYNTACS(X) coordinates. XYCCNV with appropriate data will convert DYNTACS(X) coordinates into UTM coordinates. These subroutines are included for reference. They can easily be eliminated if not required. The dimensions of several commons and the values of several variables are situation-dependent and need to be checked prior to the use of the FEATUR program. Be sure to allow for extra parallelograms and circles if dynamically emplaced minefields are used. The data cards for all parallelograms are placed first in the data deck, followed by the input data for circles.

6. The FEATUR program and a sample JCL setup for the IBM 360-91 at APL are attached as inclosure A-III-a. The FEATUR program sets up a job stream of three steps: the first step scratches the old source and object modules, the second compiles and executes the FEATUR program (FT06 is printed output, FT07 is stored on disc, FT08 is a dummy), the third step uses the card image data created in step 2 to generate and store an object module on disk. The object module created in step 3 is accessed in the link edit step of the DYNTACS(X) job stream to provide the required environmental data.

INPUT CARD FOR PARALLELOGRAM

COLUMN(S)	DATA ITEM
1- 6	X coordinate of 1st corner
7-12	Y coordinate of 1st corner
13-18	X coordinate of 2nd corner
19-24	Y coordinate of 2nd corner
25-30	X coordinate of 3rd corner
31-36	Y coordinate of 3rd corner
37-42	X coordinate of 4th corner
43-48	Y coordinate of 4th corner
49-51	index for concealment
52-54	index for cover
55-57	index for trafficability
58-60	index for roughness
61-63	index for minefields
64-66	index for smoke
67-69	code for degree of knowledge
70-72	figure reference number
73-79	blank
80	special figure identifier

Figure A-III-1

INPUT CARD FOR CIRCLE

COLUMN(S)	DATA ITEM
1- 6	X coordiantes of center
7-12	Y coordinates of center
13-18	radius
19-21	index for concealment
22-24	index for cover
25-27	index for trafficability
28-30	index for roughness
31-33	index for minefields
34-36	index for smoke
37-39	code for degree of knowledge
40-42	figure reference number
43-79	blank
80	special figure identifier

Figure A-III-2

Inclosure A-III-a

FEATUR Program

```
//CACDA99 JOB (XXXXCDCA,C,U,Q),WELLS
//SCRATCH EXEC PGM=IEFBR14
//OBJECT DD DISP=(OLD,DELETE),
//            DSN=NAME.CDEA.ONWEST.FEATURES
//SOURCE DD DISP=(OLD,DELETE),
//            DSN=NAME.CDEA.NWEST.FEATURES
/*
//FULDA EXEC FG,REGION.G=200K
//F.SYSIN DD *
C        FEATURES                                                       C
C                                                                       0
C PROGRAM TO READ PARALLELOGRAM AND CIRCULAR FEATURE DATA AND GENERATE  0
C A BLOCK DATA PROGRAM FOR DYNTACS                                      0
C                                                                       0
C COMMON AREAS INITIALIZED ARE-                                         0
C      COMMON/MINTRU/LIMITC,LIMITM,LIMITP
C      COMMON/TDDATA/NMBRCR,NMBRPL,NUMFC,NUMFP,NMINC,NMINP
C      COMMON/MINC/MINC(MAXMC)                                          0
C      COMMON/MINP/MINP(MAXMP)                                          0
C      COMMON/TD/TD(7,LIMITC+LIMITP)                                    0
C      COMMON/TDC/TDC(3,LIMITC)
C      COMMON/TDP/TDP(7,LIMITP)                                         0
C      COMMON/TDFC/TDFC(NUMFC)
C      COMMON/TDFP/TDFP(NUMFP)                                          C
C *** THIS PROGRAM IS DIMENSIONES FOR 353 PARALLELOGRAMS AND 90 CIRCLES C
C                                                                       0
C MAXMC = MAXIMUM NUMBER OF CIRCULAR MINEFIELDS ALLOWED
C NMINC = NUMBER OF CIRCULAR MINEFIELDS IN INPUT DATA                   0
C MAXMP = MAXIMUM NUMBER OF PARALLELOGRAM MINEFIELDS ALLOWED
C NMINP = NUMBER OF PARALLELOGRAM MINEFIELDS IN INPUT DATA
C NUMFC = NUMBER OF CIRCULAR FORESTS IN INPUT DATA                      0
C NUMFP = NUMBER OF PARALLELOGRAM FORESTS IN INPUT DATA
C MAXM  = MAXIMUM NUMBER OF MINEFIELDS ALLOWED
      DIMENSION YM(353),YINTSM(353),YINTLR(353),
     *          XM(353),XINTSM(353),XINTLR(353),
     *          NMB(13 ),X(9  ),Y(9 0),
     *          NMBPFT(353,7),NMBCFT(900,7),R(900),
     *          SORT(900),XMIN(9  ),ITREEP(3  ),
     *          ITREEC(9  ),ITEMP6(7),ITEMP4(7)
      DIMENSION MINP(300),MINC(300)
      INTEGER FLAG,F
      INTEGER*2 TD,TDFC,TDFP,MINC,MINP
      MINE=5
      READ (5,1000) F
1000  FORMAT (A1)
      NMINC = 0
      NMINP =
      NUMFC = 0
      NUMFP = 0
      WRITE(6,1)
    1 FORMAT (28H1ORIGINAL PARALLELOGRAM DATA/1H ,9X,7HPOINT 1,13X,7HPOI
     *NT 2,13X,7HPOINT 3,13X,7HPOINT 4/8X,1HX,9X,1HY,9X,1HX,9X,1HY,9X,1H
     *X,9X,1HY,9X,1HX,9X,1HY,3X,3HCON,2X,5HCOV  ,5HTRF  ,5HR1.  ,5HMF.
     *,5HSMK  ,7HROB    ,1HN)
C MAXP  = MAXIMUM NUMBER OF PARALLELOGRAMS ALLOWED
C NMBRPL= NUMBER OF PARALLELOGRAMS IN INITIAL DATA
C IF MAXP.GT.NMBRPL THEN EXTRA PARALLELOGRAMS ARE FILLED WITH TRIVIA
      READ(5,2) MAXP,NMBRPL
    2 FORMAT(2I5)
      DO 5  I=1,NMBRPL
C *** A PARALLELOGRAM WILL BE READ SPECIFYING 4 CONSECUTIVE POINTS
C *** THEN EACH PARALLELOGRAM WILL BE RESPECIFIED PER LCTF SUBROUTINE
      READ(5,3) X1,Y1,X2,Y2,X3,Y3,X4,Y4,(NMBPFT(I,J),J=1,7),NMB(I),FLAG
    3 FORMAT(8F6.0,8I3,7X,A1)
```

```
      .T..CC (I)=FLAG
      IF (X1.GT.45     .) GO TO 17321
      XXX1=52325.
      YYY1=9265.
      AANGG=-.8874
      CALL XYCCNV (XXX1,YYY1,AANGG,X1,Y1,XX11,YY11)
      X1=XX11
      Y1=YY11
      CALL XYCCNV (XXX1,YYY1,AANGG,X2,Y2,XX22,YY22)
      X2=XX22
      Y2=YY22
      CALL XYCCNV(XXX1,YYY1,AANGG,X3,Y3,XX33,YY33)
      X3=XX33
      Y3=YY33
      CALL XYCCNV (XXX1,YYY1,AANGG,X4,Y4,XX44,YY44)
      X4=XX44
      Y4=YY44
17321 CONTINUE
      CALL XYCONV (X1,Y1)
      CALL XYCONV (X2,Y2)
      CALL XYCONV (X3,Y3)
      CALL XYCONV (X4,Y4)
  883 WRITE(6,7) X1,Y1,X2,Y2,X3,Y3,X4,Y4,(NMBPFT(I,J),J=1,7),NMB(I),FLAG
    7 FORMAT(8F10.1,8I5,A1)
C TEST IF DATA POINTS REPRESENT A PARALLELOGRAM
      IF(ABS(X1+X3-X2-X4).LE.0.1.AND.ABS(Y1+Y3-Y2-Y4).LE.0.1) GO TO 88
C TEST IF PARALLELOGRAM BUT DATA POINTS NOT IN PROPER ORDER
      IF(ABS(X1+X4-X2-X3).LE.0.1.AND.ABS(Y1+Y4-Y2-Y3).LE.0.1) GO TO 99
C DATA POINTS NOT A PARALLELOGRAM.  FIX (X4,Y4)
      X4=X1+X3-X2
      Y4=Y1+Y3-Y2
      GO TO 88
C DATA POINTS NOT IN PROPER ORDER.  FIX POINTS 3 AND 4.
   99 TEMP=X4
      X4=X3
      X3=TEMP
      TEMP=Y4
      Y4=Y3
      Y3=TEMP
   88 CONTINUE
      IF (X1-X2) 9,10,9
9     IF (Y2-Y3) 20,10,20
   10 CONTINUE
C *** ONE SIDE IS PARALLEL TO AN AXIS, AND IT IS NECESSARY TO ROTATE
      TEMPX = X1
      TEMPY = Y1
      X1 = X4
      Y1 = Y4
      X4 = X3
      Y4 = Y3
      X3 = X2
      Y3 = Y2
      X2 = TEMPX
      Y2 = TEMPY
   20 XMIN(I) = AMIN1(X1,X2,X3,X4)
      WRITE (8,15) X1,Y1,X2,Y2,X3,Y3,X4,Y4
   15 FORMAT (8F6.0)
C *** CALCULATE SLOPES AND INTERCEPTS
C *** YM = Y SLOPE
C *** YINTSM = SMALLEST Y INTERCEPT
C *** YINTLR = LARGEST Y INTERCEPT
C *** XM = X SLOPE
C *** XINTSM = SMALLEST X INTERCEPT
C *** NMBPFT = IDENTIFYING NUMBER OF THE PARALLELOGRAM FEATURE
C *** XINTLR = LARGEST X INTERCEPT
C *** NMB = ORIGINAL FEATURE NUMBER
```

```
      YINTSM(I) = Y2-YM(I)*X2
      YINTLR(I) = Y3-YM(I)*X3
      IF (YINTSM(I)-YINTLR(I)) 25,32,32
32    TEMP=YINTSM(I)
      YINTSM(I) = YINTLR(I)
      YINTLR(I) = TEMP
   25 XM(I) = (X2-X3) / (Y2-Y3)
      XINTSM(I) = X2-XM(I)*Y2
      XINTLR(I) = X1-XM(I)*Y1
      IF (XINTSM(I)-XINTLR(I)) 50,27,27
27    TEMP=XINTSM(I)
      XINTSM(I) = XINTLR(I)
      XINTLR(I) = TEMP
   50 CONTINUE
C *** NOW SORT ARRAY
      IF (NMBRPL-1) 101,45,45
45    DO 100 I=1,NMBRPL
      TEMP=XMIN(I)
      K=I
      DO 75 J=I,NMBRPL
      IF (TEMP-XMIN(J)) 75,47,47
47    TEMP=XMIN(J)
      K= J
   75 CONTINUE
      TEMP1 = YM(K)
      TEMP15 =  YINTSM(K)
      TEMP2 = YINTLR(K)
      TEMP3 = XM(K)
      TEMP4 = XINTSM(K)
      TEMP5 = XINTLR(K)
      DO 21  M=1,7
   21 ITEMP6(M) = NMBPFT(K,M)
      FLAG=ITREEP(K)
      ITEMP7 = NMB(K)
      XMIN(K) = XMIN(I)
      YM(K) = YM(I)
      YINTSM(K) = YINTSM(I)
      YINTLR(K) = YINTLR(I)
      XM(K) = XM(I)
      XINTSM(K) = XINTSM(I)
      XINTLR(K) = XINTLR(I)
      DO 22 M=1,7
   22 NMBPFT(K,M) = NMBPFT(I,M)
      ITREEP(K)=ITREEP(I)
      NMB(K) = NMB(I)
      XMIN(I)=TEMP
      YM(I) = TEMP1
      YINTSM(I) = TEMP15
      YINTLR(I) = TEMP2
      XM(I) = TEMP3
      XINTSM(I) = TEMP4
      XINTLR(I) = TEMP5
      DO 23 M=1,7
   23 NMBPFT(I,M) = ITEMP6(M)
C **  CHECK IF FOREST
      IF (FLAG-F) 24,42,24
C *** THIS FEATURE IS A FOREST
42    NUMFP=NUMFP+1
      ITREEP(NUMFP) = I
   24 CONTINUE
      NMB(I) = ITEMP7
C *** CHECK IF MINEFIELD
      IF (NMBPFT(I,MINE)) 49,100,49
C **  THIS FEATURE IS A MINEFIELD
49    NMINP=NMINP+1
```

```
  100 CONTINUE
  101 CONTINUE
      WRITE (6,102)
  1 2 FORMAT (27H1REVISED PARALLELOGRAM DATA/8H0    XMIN,12X,2HYM,8X,6HYI
     *NTSM,8X,6HYINTLR,12X,2HXM,8X,6HXINTSM,8X,6HXINT_R,7X,7HCODES   ,3X,
     *12HOLD N   NEW N)
      DO 110 I=1,NMBRPL
  110 WRITE (6,4) XMIN(I),YM(I),YINTSM(I),YINTLR(I),XM(I),XINTSM(I),XINT
     *LR(I),(NMBPFT(I,J),J=1,7),NMB(I),I
    4 FORMAT (F7.0,6E14.5,7I2,I8,I7)
      IF(MAXP.LE.NMBRPL) GO TO 115
C FILL IN REMAINING PARALLELOGRAMS WITH TRIVIAL DATA
      ITEMP7=NMBRPL+1
      DO  90 I=ITEMP7,MAXP
      XMIN(I)=9999999.
      YM(I)=0.
      YINTSM(I)=0.
      YINTLR(I)=0.
      XM(I)=0.
      XINTSM(I)=9999999.
      XINTLR(I)=9999999.
      ITREEP(I)=0.
      NMB(I)=I
      DO 90 M=1,7
   90 NMBPFT(I,M)=0
      WRITE(6,91) ITEMP7,MAXP
   91 FORMAT(29H0**** PARALLELOGRAMS NUMBERED,I4, 8H THROUGH,I4,
     *30H ARE FILLED WITH TRIVIAL DATA.)
  115 WRITE(6,120)
  120 FORMAT(21H1ORIGINAL CIRCLE DATA/1H0,7X,1HX,9X,1HY,4X,6HRADIUS,7X,3
     *HX-R,3X,40HCON   COV   TRF   RT.   MF.   SMK  ROB    N    )
C MAXC  = MAXIMUM NUMBER OF CIRCLES ALLOWED
C NMBRCR= NUMBER OF CIRCLES IN INPUT DATA
      READ(5,2) MAXC,NMBRCR
C READ CIRCULAR DATA
      DO 150 I=1,NMBRCR
      READ(5,6) X(I),Y(I),R(I),(NMBCFT(I,J),J=1,7),NMB(I),FLAG
    6 FORMAT(3F6.0,8I3,37X,A1)
      ITREEC(I)=FLAG
      IF (X(I).GT.45000.) GO TO 17322
      CALL XYCCNV (XXX1,YYY1,AANGG,X(I),Y(I),XX11,YY11)
      X(I)=XX11
      Y(I)=YY11
17322 CONTINUE
      CALL XYCONV (X(I),Y(I))
      AAA=0.
      WRITE (8,19) X(I),Y(I),R(I),AAA
   19 FORMAT (3F6.0,24X,F6.0)
 887  SORT(I) = X(I)-R(I)
  703 WRITE (6,121) X(I),Y(I),R(I),SORT(I),(NMBCFT(I,J),J=1,7),NMB(I)
     *,FLAG
  121 FORMAT (4F10.1,8I5,A1)
  150 CONTINUE
C *** NOW SORT ARRAY
      IF (NMBRCR-1) 201,160,160
160   DO 20  I=1,NMBRCR
      TEMP = SORT(I)
      K=I
      DO 175 J=I,NMBRCR
      IF (TEMP-SORT(J)) 175,161,161
161   TEMP=SORT(J)
      K=J
  175 CONTINUE
      TEMP1 = X(K)
      TEMP2 = Y(K)
```

```
      DO 51 M=1,7
   51 ITEMP4(M)=NMBCFT(K,M)
      FLAG=ITREEC(K)
      ITEMP5 = NMB(K)
      X(K) = X(I)
      Y(K) = Y(I)
      R(K) = R(I)
      SORT(K) = SORT(I)
      DO 52 M=1,7
   52 NMBCFT(K,M)=NMBCFT(I,M)
      ITREEC(K)=ITREEC(I)
      NMB(K) = NMB(I)
      X(I) = TEMP1
      Y(I) = TEMP2
      R(I) = TEMP3
      SORT(I) = TEMP
      DO 53  M=1,7
   53 NMBCFT(I,M) = ITEMP4(M)
C *** CHECK IF FOREST
      IF (FLAG-F) 54,163,54
C *** THIS FEATURE IS A FOREST
163   NUMFC=NUMFC+1
      ITREEC(NUMFC) = I
   54 CONTINUE
      NMB(I) = ITEMP5
C *** CHECK IF MINEFIELD
      IF (NMBCFT(I,MINE)) 165,200,165
C *** THIS FEATURE IS A MINEFIELD
165   NMINC=NMINC+1
      MINC(NMINC) = I
  200 CONTINUE
  201 CONTINUE
      WRITE(6,202)
  202 FORMAT (20H1REVISED CIRCLE DATA/1H0,11X,1HX,18X,1HY,13X,6HRADIUS,7
     *X,3HX-R,3X,40HCON  COV  TRF  RT.  MF.  SMK  ROB  N  )
      DO 210 I=1,NMBRCR
      J=I+NMBRPL
   21 WRITE(6,5) X(I),Y(I),R(I),SORT(I),(NMBCFT(I,M),M=1,7),NMB(I),J
    5 FORMAT(E13.5,3E19.5,7I3,1X,I10,I14)
C TEST IF THERE ARE EXTRA CIRCLES
      IF(MAXC.LE.NMBRCR) GO TO 300
C FILL IN EXTRA CIRCLES WITH TRIVIAL DATA
      ITEMP7=NMBRCR+1
      DO 92 I=ITEMP7,MAXC
      X(I)=9999999.
      Y(I)=0.
      R(I)=0.
      DO 92 M=1,7
   92 NMBCFT(I,M)=0
   93 WRITE(6,94) ITEMP7,MAXC
   94 FORMAT(22H0**** CIRCLES NUMBERED,I4,8H THROUGH,I4,
     *30H ARE FILLED WITH TRIVIAL DATA.)
C COMPUTE MAXIMUM NUMBER OF-
C          PARALLELOGRAM MINEFIELDS
  300 MAXP=MAX0(MAXP,NMBRPL)
      MAXMP=MAXP-NMBRPL+NMINP
C          CIRCULAR MINEFIELDS
      MAXC=MAX0(MAXC,NMBRCR)
      MAXMC=MAXC-NMBRCR+NMINC
C          MINEFIELDS
      MAXM=MAXMP+MAXMC
C *** NOW PUNCH CARDS
      WRITE(7,1111)
 1111 FORMAT(6X,'BLOCK DATA')
      WRITE(7,95)
```

```
   95 FORMAT(6X,34HCOMMON/MINTP/LIMITC,LIMITM,LIMITP)
      WRITE (7,123)
  123 FORMAT(6X,'COMMON/TDDATA/NMBRCR,NMBRPL,NUMFC,NUMFP,NMINC,NMINP')
      KNUMFC=NUMFC
      KNMINC = MAXMC
      IF (KNMINC) 1015,1015,1017
 1015 KNMINC=1
 1017 WRITE (7,133) KNMINC
  133 FORMAT(6X,'COMMON/MINC/MINC(',I4,')')
      KNMINP = MAXMP
      IF (KNMINP) 1011,1011,1013
 1011 KNMINP=1
 1013 WRITE (7,132) KNMINP
  132 FORMAT(6X,'COMMON/MINP/MINP(',I4,')')
      NTFTR=MAX0(1,MAXP+MAXC)
 1029 WRITE (7,128) NTFTR
  128 FORMAT(6X,15HCOMMON/TD/TD(7,,I4,1H))
      KMBRCR=MAX0(1,MAXC)
 1025 WRITE (7,124) KMBRCR
  124 FORMAT(6X,17HCOMMON/TDC/TDC(3,,I4,1H))
      KMBRPL=MAX0(1,MAXP)
 1007 KNUMFP=1
 1009 WRITE (7,4444) KNUMFP
 4444 FORMAT(6X,17HCOMMON/TDFP/TDFP(,I4,1H))
      WRITE(7,5555)
 5555 FORMAT(6X,33HINTEGER*2 TDFC,TDFP,TD,MINC,MINP  )
      WRITE(7,96) MAXC,MAXM,MAXP
   96 FORMAT(6X,12HDATA LIMITC/,I4,1H//6X,12HDATA LIMITM/,I4,1H//
     *6X,12HDATA LIMITP/,I4,1H/)
      WRITE (7,114) NMBRPL
  114 FORMAT(6X,12HDATA NMBRPL/,I4,1H/)
      WRITE (7,119) NMBRCR
  119 FORMAT(6X,12HDATA NMBRCR/,I4,1H/)
      WRITE (7,116) NUMFP
  116 FORMAT(6X,11HDATA NUMFP/,I4,1H/)
      WRITE (7,117) NUMFC
  117 FORMAT(6X,11HDATA NUMFC/,I4,1H/)
      WRITE (7,130) NMINP
  130 FORMAT(6X,'DATA NMINP/',I4,'/')
      WRITE (7,131) NMINC
  131 FORMAT(6X,'DATA NMINC/',I4,'/')
      DO 500 I=1,MAXP
  500 WRITE (7,109) I,I,I,I,I,I,I,XMIN(I),YM(I),YINTSM(I),YINTLR(I),XM(I
     1),XINTSM(I),XINTLR(I)
  109 FORMAT(6X,11HDATA TDP(1,,I4,8H),TDP(2,,I4,8H),TDP(3,,I4,8H),TDP(4,
     *,I4,8H),TDP(5,,I4,3H),T/5X,6H*DP(6,,I4,8H),TDP(7,,I4,2H)/,E16.8,1H
     *,,E16.8,1H,/5X,1H*,E16.8,1H,,E16.8,1H,,E16.8,1H,/5X,1H*,E16.8,1H,,
     *E16.8,1H/)
      DO 550 I=1,MAXC
  550 WRITE (7,125) I,I,I,X(I),Y(I),R(I)
  125 FORMAT(6X,11HDATA TDC(1,,I4,8H),TDC(2,,I4,8H),TDC(3,,I4,2H)/,E16.8
     *,1H,/5X,1H*,E16.8,1H,,E16.8,1H/)
      DO 650 I=1,MAXP
  650 WRITE (7,111) I,I,I,I,I,I,I,(NMBPFT(I,J),J=1,7)
  111 FORMAT(6X,10HDATA TD(1,,I4,7H),TD(2,,I4,7H),TD(3,,I4,7H),TD(4,,I4,
     *7H),TD(5,,I4,2H),/5X,6H*TD(6,,I4,7H),TD(7,,I4,2H)/,I2,1H,,I2,1H,,I
     *2,1H,,I2,1H,,I2,1H,,I2,1H,,I2,1H/)
      DO 51  L=1,MAXC
      K=L+MAXP
  510 WRITE(7,111)K,K,K,K,K,K,K,(NMBCFT(L,J),J=1,7)
      IF (NUMFP) 600,600,511
  511 DO 512 I=1,NUMFP
  512 WRITE (7,126) I,ITREEP(I)
  126 FORMAT(6X,10HDATA TDFP(,I4,2H)/,I4,1H/)
  600 IF (NUMFC) 211,211,611
  611 DO 612 I=1,NUMFC
```

```
612    WRITE (7,127) I,I...
  127 FORMAT(6X,1 HDATA TDFC(,I4,2H)/,I4,1H/)
  211 IF(MAXMC) 704,704,705
  705 DO 706 I=1,MAXMC
      IF(I.GT.NMINC) MINC(I) = 0
706   WRITE (7,134) I,MINC(I)
  134 FORMAT(6X,'DATA MINC(',I4,')/',I4,'/')
  704 IF(MAXMP) 707,707,708
  708 DO 709 I=1,MAXMP
      IF(I.GT.NMINP) MINP(I) = 0
709   WRITE (7,135) I,MINP(I)
  135 FORMAT(6X,'DATA MINP(',I4,')/',I4,'/')
  707 CONTINUE
      WRITE (7,2222)
 2222 FORMAT(6X,3HEND)
      STOP
      END
      SUBROUTINE XYCONV(X,Y)
      XDF = X - 47723.17
      IF(Y.LT.88000.0) Y = Y + 100000.0
      YDF = Y - 89947.98
      ANG = 0.89980
      SINE = SIN(ANG)
      COSINE = COS(ANG)
      X = XDF * COSINE + YDF * SINE
      Y = YDF * COSINE - XDF * SINE
      RETURN
      END
      SUBROUTINE XYCCNV (XP,YP,ANG,XIN,YIN,XOUT,YOUT)
      SINE=SIN(ANG)
      COSINE=COS(ANG)
      XOUT=XIN*COSINE+YIN*SINE
      YOUT=YIN*COSINE-XIN*SINE
      XOUT=XOUT+XP
      YOUT=YOUT+YP
      RETURN
      END
/*
//G.FT06F001 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=6384)
//G.FT07F001 DD UNIT=SAVE,DISP=(NEW,CATLG),
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=6400),
//             SPACE=(TRK,(9,5),RLSE),
//             DSN=NAME.COEA.NWEST.FEATURES
//G.FT08F001 DD DUMMY
//G.SYSIN DD *
F
  353  257
10469. 2305.10424. 1203. 9484. 1824. 9549. 2927.  0  0  0  1  0  0  3016
 9896.  477.10242. -131. 9995. -111. 9650.  497.  0  0  0  1  0  0  3017
 9567. 1097. 9609.  452. 9272.  425. 9230. 1070.  0  0  0  1  0  0  3018
 8938.  619. 9053.  -70. 8899. -181. 8783.  508.  0  0  0  1  0  0  3019
 7162.  517. 7242.  401. 7003.  236. 6923.  351.  0  0  0  1  0  0  3020
 7134.  648. 7157.  603. 6956.  518. 6932.  564.  0  0  0  1  0     3021
 6521. 1157. 6417.  856. 5950. 1007. 6054. 1309.  0  0  0  1  0  0  3022
 4579.  704. 4488.  465. 4106.  415. 4196.  654.  0  0  0  1  0  0  3023
10416. 4005.10157. 3208. 9026. 3853. 9207. 4587.  0  0  0  1  0  0  3026
 9667.  716.10570.  324. 5710. 5772. 4808. 6164.  0  0  0  1  0  0  3027
 9654. 1436. 9770. 1387. 9742.  430. 9626.  478.  0  0  0  1  0  0  3028
 9648.  995. 9781. 1037. 9921.  445. 9789.  403.  0  0  0  1  0     3029
 9097. 2052. 9331. 1792. 9150. 1698. 8916. 1959.  0  0  0  1  0     3031
 912 . 1815. 9048. 1681. 8 50. 2368. 8122. 25 2.  0  0  0  1  0     3032
 6760.  875. 6821.  654. 6726.  629. 6665.  850.  0  0  0  1  0  0  3033
 6204. 5027. 6276. 4905. 5934. 4708. 5862. 4830.  0  0  0  1  0  0  3034
 6204.  929. 6078.  687. 5886.  751. 6012.  993.  0  0  0  1  0  0  3035
 5675. 1159. 5705. 1106. 5513. 1041. 5483. 1095.  0  0  0  1  0  0  3036
 4092.  289. 4445.  -57. 3793. -219. 3440.  126.  0  0  0  1  0  0  3037
```

[illegible]	[illegible]	3959.	631.	[illegible]	216.	[illegible]	[illegible]				1			[illegible]
3539.	1396.	3603.	-77.	3465.	-289.	34[illegible]1.	1183.	[illegible]	[illegible]	[illegible]	1	0	0	3039
5701.	5047.	5712.	4826.	5420.	4822.	54[illegible]9.	5[illegible]44.	0	[illegible]	0	2	0	[illegible]	3040
9010.	5313.	9755.	5359.	9691.	5167.	8946.	5121.	0	[illegible]	5	[illegible]	0	[illegible]	3041
7983.	33[illegible].	8303.	24[illegible]4.	8[illegible]46.	2582.	7726.	3478.	[illegible]	[illegible]	4	[illegible]	0	[illegible]	3042
8776.	2308.	8939.	2[illegible]41.	8311.	2410.	8148.	2677.	0	[illegible]	4	0	0	0	3043
8789.	2229.	8876.	2[illegible]55.	8552.	1117.	8465.	1291.	0	[illegible]	1	0	0	0	3044
8483.	1395.	8466.	472.	8179.	703.	8196.	1626.	0	[illegible]	3	0	0	0	3045
8647.	5304.	8657.	5082.	7519.	4312.	7509.	4534.	0	[illegible]	4	0	0	[illegible]	3046
6635.	3464.	6417.	3289.	5542.	3294.	576[illegible].	3469.	[illegible]	[illegible]	4	[illegible]	0	[illegible]	3047
5767.	3461.	5659.	3259.	4974.	2980.	5082.	3182.	[illegible]	[illegible]	4	[illegible]	0	[illegible]	3048
8043.	1593.	8172.	1287.	8054.	795.	7925.	1101.	0	[illegible]	4	0	[illegible]	[illegible]	3049
7088.	4274.	7147.	41[illegible]4.	6874.	3886.	6815.	4056.	[illegible]	[illegible]	4	[illegible]	0	[illegible]	3050
619[illegible].	3748.	6537.	3411.	6378.	3130.	6031.	3467.	[illegible]	[illegible]	3	0	0	0	3051
6434.	2035.	6642.	1919.	6446.	1443.	6238.	1559.	[illegible]	[illegible]	4	0	0	[illegible]	3052
5612.	431[illegible].	5369.	3846.	5111.	3896.	5354.	436[illegible].	[illegible]	[illegible]	4	0	0	0	3053
513[illegible].	4769.	5223.	4652.	5176.	4615.	5083.	4732.	0	[illegible]	4	0	0	0	3054
5003.	4463.	5166.	4260.	4774.	4254.	4611.	4457.	[illegible]	[illegible]	4	0	0	[illegible]	3055
456[illegible].	2840.	4635.	2747.	4344.	2374.	4269.	2467.	0	[illegible]	4	0	0	0	3056
3765.	4074.	3829.	3818.	3713.	3802.	3649.	4058.	[illegible]	[illegible]	4	[illegible]	0	[illegible]	3057
9262.	4567.	9315.	4532.	9339.	41[illegible]3.	9286.	4138.	[illegible]	[illegible]	4	0	0	0	3058
8861.	21[illegible]7.	9251.	1971.	9253.	1921.	8863.	2057.	0	[illegible]	4	0	0	0	3059
9139.	767.	9425.	586.	9462.	475.	9176.	656.	0	0	4	0	0	[illegible]	3060
6593.	3340.	6774.	3178.	6735.	3147.	6554.	3309.	0	0	4	0	0	0	3061
5777.	1048.	5808.	1009.	5600.	932.	5569.	971.	0	0	4	0	0	0	3062
5653.	7[illegible]6.	5727.	47[illegible].	5694.	431.	562[illegible].	667.	0	0	4	0	0	0	3063
5186.	1113.	5353.	824.	5278.	854.	5111.	1143.	0	0	4	0	0	0	3064
9342.	1506.	9398.	1435.	9294.	1390.	9238.	1461.	0	0	4	0	0	0	3065
8976.	1418.	9008.	1379.	8873.	1387.	8841.	1426.	0	0	4	0	0	[illegible]	3066
8062.	4721.	8087.	469[illegible].	7947.	4578.	7922.	46[illegible]9.	0	[illegible]	4	0	0	0	3067
7894.	4292.	8064.	4223.	8017.	4186.	7847.	4255.	0	0	4	0	0	0	3068
76[illegible].	3900.	7683.	3803.	7621.	3753.	7582.	3850.	0	0	4	0	0	0	3069
7593.	2027.	7722.	1785.	7629.	1710.	750[illegible].	1952.	0	0	4	0	0	0	3070
7554.	1292.	7579.	1260.	7426.	1228.	7401.	126[illegible].	0	0	4	0	0	0	3071
7608.	1271.	7640.	1232.	7457.	1189.	7425.	1228.	0	0	4	0	0	0	3072
7285.	2396.	7344.	2290.	7321.	2271.	7262.	2377.	0	0	4	0	0	0	3073
7369.	2258.	7454.	2185.	7415.	2154.	733[illegible].	2227.	[illegible]	[illegible]	4	0	0	[illegible]	3074
7225.	41[illegible]3.	7257.	4064.	7238.	3959.	7206.	3998.	0	0	4	0	0	0	3075
7[illegible]82.	3834.	7044.	3561.	6990.	3517.	7028.	3790.	0	0	4	0	0	0	3076
7010.	3828.	6987.	3617.	6940.	3579.	6963.	3790.	0	0	4	0	0	[illegible]	3077
7017.	875.	7[illegible]42.	843.	6953.	811.	6928.	843.	0	0	4	0	0	[illegible]	3078
7121.	856.	7140.	832.	6984.	771.	6965.	795.	0	0	4	0	0	0	3079
6679.	4370.	6866.	4135.	6835.	4110.	6648.	4345.	0	0	4	0	0	0	3080
6429.	3337.	6590.	3184.	6559.	3159.	6398.	3312.	0	[illegible]	4	0	0	0	3081
6548.	21[illegible].	6617.	2[illegible]15.	6551.	1872.	6482.	1957.	0	0	4	0	0	0	3082
6426.	4782.	6473.	4691.	6387.	4623.	6340.	4714.	0	0	4	0	0	0	3083
5322.	3425.	5358.	3364.	5326.	3339.	5290.	3400.	0	0	4	0	0	0	3084
5278.	3864.	5303.	3832.	5258.	3745.	5233.	3777.	0	0	4	0	0	0	3085
5225.	3898.	525[illegible].	3867.	5219.	3778.	5194.	38[illegible]9.	0	0	4	0	0	0	3086
4821.	2691.	4846.	2659.	4742.	2628.	4717.	2660.	0	0	4	0	0	0	3087
4265.	1721.	4296.	1682.	4238.	1546.	4207.	1585.	0	0	4	0	0	0	3088
3192.	3910.	3224.	3757.	3185.	3726.	3153.	3879.	0	0	4	0	0	[illegible]	3089
4[illegible]27.	289.	4[illegible]88.	196.	4[illegible]26.	146.	3965.	239.	[illegible]	[illegible]	4	[illegible]	0	[illegible]	3090
4046.	3147.	4101.	2934.	4[illegible]62.	2903.	4007.	3116.	0	0	4	0	0	0	3091
9419.	594.	94[illegible]8.	-273.	9[illegible]38.	-275.	9[illegible]48.	592.	0	0	1	0	0	0	3092
8658.	792.	8728.	-240.	8372.	-244.	8302.	789.	0	0	1	0	0	0	3093
3818.	5000.	3993.	4718.	3571.	4700.	3396.	4983.	0	0	1	0	0	[illegible]	3094
3815.	4972.	4[illegible]52.	4291.	3691.	3798.	3454.	4479.	0	0	1	0	0	0	3095
3994.	4219.	3979.	4[illegible]15.	3758.	3698.	3774.	39[illegible]2.	0	0	1	0	0	0	3096
10552.	2346.	10577.	-54.	9733.	-103.	9707.	2298.	0	0	2	0	0	0	3097
10335.	3338.	10374.	2152.	9593.	2232.	9542.	3433.	[illegible]	[illegible]	2	[illegible]	0	[illegible]	3098
9319.	1231.	94[illegible]3.	517.	871[illegible].	615.	8613.	1345.	[illegible]	[illegible]	2	[illegible]	0	[illegible]	3099
8648.	3525.	8449.	2430.	8110.	2518.	8309.	3612.	0	0	2	0	0	0	3100
8689.	3378.	9265.	28[illegible]2.	8733.	2299.	8156.	2875.	0	[illegible]	2	0	0	0	3101
8450.	2700.	9308.	1965.	9161.	1796.	8303.	2532.	0	0	2	0	0	0	3102
7911.	11[illegible]7.	8253.	1171.	8[illegible]57.	-122.	8222.	-12[illegible].	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	3103

654 .	2158.	7660.	647.	5808.	625.	4688.	2136.	0	0	2	0	0	0	3105
6284.	365.	6269.	-159.	5649.	-169.	5664.	356.	0	0	2	0	0	0	3106
5584.	5146.	4719.	4530.	3974.	4485.	4839.	51 .	0	0	2	0	0	0	3107
4043.	5103.	4620.	4413.	4257.	4404.	3679.	5094.	0	0	2	0	0	0	3108
4193.	1714.	4241.	1190.	3518.	829.	347 .	1354.	0	0	2	0	0	0	3109
3649.	1369.	3434.	-250.	3128.	-252.	3343.	1368.	0	0	2	0	0	0	3110
3635.	3868.	3634.	3662.	3092.	3459.	3093.	3665.	0	0	2	0	0	0	3111
9610.	5204.	9281.	4863.	8162.	4852.	8445.	5155.	0	0	3	0	0	0	3112
9252.	5187.	9190.	3920.	9 26.	3917.	9 81.	5177.	0	0	3	0	0	0	3113
9050.	4000.	9712.	3492.	9721.	3321.	9059.	3828.	0	0	3	0	0	0	3114
9563.	3566.	9532.	2580.	9362.	2585.	9393.	3570.	0	0	3	0	0	0	3115
9339.	2246.	9693.	1531.	9612.	1504.	9258.	2219.	0		3	0	0		3116
9768.	1565.	9778.	1457.	9094.	1512.	9084.	162 .	0	0	3	0	0	0	3117
8586.	5012.	8658.	3673.	8500.	3662.	8428.	5001.	0	0	3	0	0	0	3118
8467.	4392.	8512.	4223.	7429.	3305.	7383.	3473.	0	0	3	0	0	0	3119
7903.	2391.	9134.	1621.	9130.	1451.	7899.	2221.	0	0	3	0	0	0	3120
8767.	879.	9220.	-39.	9127.	-50.	8674.	868.	0	0	3	0	0	0	3121
8474.	2015.	8797.	570.	8692.	589.	8369.	2034.	0	0	3	0	0	0	3122
8774.	615.	8778.	-47.	8692.	-51.	8688.	611.	0	0	3	0	0	0	3123
8441.	1784.	8531.	17 2.	7991.	1065.	7900.	1146.	0	0	3	0	0	0	3124
7502.	3453.	8000.	2238.	7810.	2124.	7311.	3339.	0	0	3	0	0	0	3125
7140.	2561.	7338.	1273.	7201.	1253.	7002.	2541.	0	0	3	0	0	0	3126
6613.	4356.	6595.	4187.	5957.	4279.	5982.	4440.	0	0	3	0	0	0	3127
647 .	4279.	6969.	3718.	6826.	3706.	6326.	4267.	0	0	3	0	0	0	3128
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//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120),
//             SPACE=(TRK,(9,5),RLSE),
//             DSN=NAME.CDEA.DNWEST.FEATURES
//F.SYSIN DD DISP=SHR,
//             DSN=NAME.CDEA.NWEST.FEATURES
/*
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ASP JOB NO. = 0235 DATE = 76.?12

//CACDA03 JOB (9601COCA,C,U,N),WELLS

ELAPSED TIME ON MAIN = M91 = 001.56, START TIME = 16.46.25

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DDNAME = ASPDA003 PRINTED ON RM059PR1, LINES = 000032
DDNAME = ASPDA006 PRINTED ON RM059PR1, LINES = 00?772
LINES OUTPUT FOR THIS JOB = 001045

CARDS FROM MAIN FOR THIS JOB = NONE

APPENDIX B

COVER PARAMETERS

1. The cover code requires that two parameters be specified for each point on the terrain: the macroterrain standard deviation and the power spectral density constant. The microterrain standard deviation is used to randomly modify the elevation of a given point on the terrain; the power spectral density constant is one factor that determines the probability of achieving hull defilade when a moving firer is seeking a firing position. A complete explanation of these concepts and the uses of the numbers is given in the section entitled "Cover" starting on page 2-29, Report AR 69-2A, The Tank Weapon System, Systems Research Group, September 1969.

2. The data requirements for estimating accurately the power spectral density function are so stringent that this procedure has only been done once, for terrain at Fort Knox, Kentucky. (See description of Aliasing, page 196-198, Report No RF-573, AR 66-2, The Tank Weapon System, Systems Research Group, December 1966.) Since the Fort Knox terrain is the only known data that meet the requirements for estimating the power spectral density function, it seems reasonable to use that data as a basis for determining the power spectral density constant required by DYNTACS(X). This procedure assumes that all terrains will have characteristics similar to the Fort Knox terrain. Although this assumption is obviously unwarrented, the procedure based on it still seems preferable to the present system of equating the power spectral density constant with the microterrain standard deviation. This is true for two reasons: 1) under the suggested procedure the terrain will have some effect on the probability of achieving hull defilade, and 2) the firing tactics will also impact on the value used. See annex A-I for a more complete discussion.

3. The microterrain standard deviation can be empirically estimated, but the procedure is not completely objective. The microterrain standard deviation is a measure of the deviation between the "actual" terrain and the macroterrain surface represented in DYNTACS(X). DYNTACS(X) traditionally uses elevations at approximately 100 meter intervals. If elevation data are available at a greater resolution than 100 meters, then sufficient information exists to allow the estimation of the microterrain standard deviation. A description of the overall procedure follows.

4. The terrain area is subdivided into smaller areas, which are judgmentally selected so that the type of terrain is relatively constant throughout the area. If the areas are small enough or the slope gentle enough, the assumption that the microterrain standard deviation is constant within a given area should be valid. After subdividing the terrain into areas, the microterrain variance is estimated (see annex B-I) for each area. Then the variance for each of the areas is compared to each of the others using an F-test. Whenever the F-test indicates that two or more areas have "essentially the same" variance, the areas can be given the same cover index. The final parameter value assigned to this index can then be computed by averaging

the variances (weighted by the number of data points) from all areas with the same index and then taking the square root of the result.

ANNEX B-I

POWER SPECTRAL DENSITY CONSTANT

1. The equation that provides the probability of achieving hull defilade by a moving firer who is assuming a temporary firing position is:

$$P = \frac{TDECOV(2)}{TDECOV(1)} \exp\left(-0.5(HA/TDECOV(1))**2\right) \qquad (1)$$

where: TDECOV(1) = microterrain standard deviation
TDECOV(2) = power spectral density constant
HA = height of cover desired

TDECOV(2) is further defined by the equation:

$$K\left(\int_{-\infty}^{\infty} w^2 S(w)dw\right)^{1/2} \qquad (2)$$

where: K = a constant depending on vehicle characteristics and tactics

SW = the power spectral density for a given terrain area

(See page 2-35 to 2-38, Report AR 69-2A, The Tank Weapon System, Systems Research Group, October 1969.)

2. Therefore, according to the DYNTACS(X) documentation, the probability of hull defilade should depend on three things: the terrain constants (TDECOV(1) and TDECOV(2)), the vehicle characteristics (width and stopping distance), and tactics. The last two factors present no problem; the vehicle characteristics and tactics can be determined with little difficulty. A procedure for determining TDECOV(1) is given in annex B-II. Only the determination of TDECOV(2) remains unresolved.

3. As indicated by equation 2 above, the power spectral density constant depends on both tactical and terrain considerations. The tactical parameters can be determined by an examination of the tactical doctrine to be represented. However, the evaluation of the integral in equation 2 is troublesome. As noted in appendix B, the function S(W) can be accurately estimated only if precise data are available. In general, these data have not been collected. A procedure for determining the value for TDECOV(2) is required in the absence of the necessary data. It must be acknowledged in advance that any procedure proposed in the absence of sufficient data will be less than accurate. However, it should make use of all available data and allow as many factors as possible to affect the process.

4. The data collected at Fort Knox were analyzed by Stollmack and Lodbill and presented in figure 90, page 204, Report FR-573, AR 66-2, The Tank Weapon System, Systems Research Group, December 1966. This figure presents the estimated power spectral density for the Fort Knox terrain. Using the information in this figure, the integral $\int_{-\infty}^{\infty} S(W)w^2dw$ can be evaluated for the Fort Knox terrain by computing the area under the graph. This Fort Knox value can then be used in the determination of the TDECOV(2) value required for DYNTACS(X).

5. The weakness in this procedure is obvious; it assumes a constant power spectral density for all terrains used in DYNTACS(X). This assumption is unwarrented but required until data are available from the terrain presently used in DYNTACS(X).

6. The advantages of this procedure are as follows:

a. The variation in terrain will have some effect on the calculated probability because the appropriate microterrain standard deviation will be used (see equation 1).

b. The effects of vehicle characteristics and tactics will be explicitly represented. The probabilities involved will conform to changes in these factors in a reasonable way.

7. The advantage in this suggested procedure will perhaps be more recognizable when it is compared to the procedure utilized in the past. Traditionally, the TDECOV(2) value has been set equal to the microterrain standard deviation (TDECOV(1)). Therefore, the traditional procedure ignores all effects of vehicle characteristics and tactics by assigning an arbitrary value to TDECOV(2), which should vary with changes in these values. The probability of achieving hull defilade will not vary with changes in terrain because the ratio of TDECOV(2) and TDECOV(1) is always one. Furthermore, the traditional procedure fails to take advantage of the data collected at Fort Knox.

8. The accurate evaluation of the power spectral density constant remains an unresolved problem. It appears that it will be resolved only when financial resources are made available to collect the required data and personnel resources are made available to analyze the data. The priority attached to this project will, of course, depend on the assessment of the adequacy of the suggested procedure and the importance this one parameter has to model results.

ANNEX B-II

MICROTERRAIN STANDARD DEVIATION

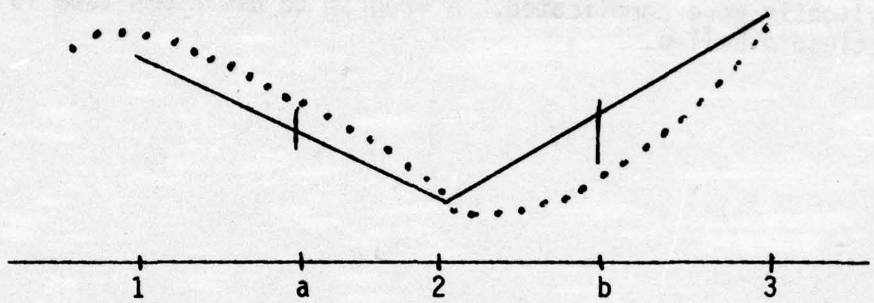

Figure B-II-1 Terrain Representation

1. In figure B-II-1 points 1, 2, and 3 represent base elevations, which would be stored in the DYNTACS(X) elevation matrix. The straight lines connecting points 1 and 2 and points 2 and 3 represent the macroterrain surface as interpolated by the DYNTACS(X) ELVATE routine. The dotted line represents the actual terrain surface. Points a and b represent intermediate points where the "actual" elevation is known. (These points are available on a DMA tape because elevations are given every 12.5 meters. When information is requested from WES, a resolution greater than that used in the model must be requested. For example, if the user intends to use elevations at 100 meter spacing in the model run, then, at a minimum, elevations at 50 meter intervals will be required for this estimation procedure.)

2. The signed difference in elevation between the "actual" terrain and the interpolated macroterrain is determined at each intermediate point. (The word "actual" is in quotes because the information provided by DMA or WES is itself an interpolated value based on the contour lines of a map.) These differences are then used to estimate the variance of the differences using the formula $\sigma^2 = \frac{\Sigma(x_i - \overline{X})^2}{n}$.

3. Two cautionary notes are in order. The formula is based on the assumption that the individual measurements are independent. If one uses points that are too close together, intuition suggests that the measurements will not be independent. Second, if measurements are taken only at the midpoint of each interval, one may bias the result by measuring at that point where the deviation is greatest. Either a subjective determination must be made

with respect to these conflicting considerations or an extensive examination of correlations between deviations measured at different intervals must be undertaken.

4. If the user has card image information from WES, the program to estimate variances is trivial to prepare. If one is using a DMA elevation tape, the procedure is slightly more complicated. A program to use a DMA tape is included at inclosure B-II-a.

INCLOSURE B-II-a

PROGRAM FOR ESTIMATION OF MICROTERRAIN DEVIATION
(MICROT)

```
DT03,T750,NT1,P1.       MURRAY
ASK,TN=TETAM,TA=18464,WP=01,DS=ATCACAM,TR=TS.
SN,INTP=4085.
ABEL,INTP,L=HLMR1755IVNE,R,D=HD.
TN,LR.
GO.

      PROGRAM MICROT(INPUT,OUTPUT,DTTP,INTP,TAPE6=OUTPUT,TAPE3=INTP,TAPE000
     15=INPUT,TAPE8=DTTP)                                              000
      DIMENSION NZ(2050)
      DIMENSION INBF(300)                                              000
    1 JP=0
      SUMDIF =0.0
      SUMPT = 0.0
      SUMSQ=0.0
C                                                                      000
C                                                                      000
C     INITIALIZE THE PROGRAM VARIABLES AND CONSTANTS  FOR              000
C     READING THE FIRST INPUT RECORD                                   000
C                                                                      000
      LUIT=3                                                           000
      LUCR=5                                                           000
      LUPR=6                                                           000
      NFORMT=13                                                        000
      ISPACE=0                                                         000
      N1=1                                                             000
      N2=2                                                             000
C                                                                      000
C     READ THE INPUT CARD                                              000
C                                                                      000
      READ(LUCR,10)IX1,IY1,IY2,IX2,NZDELT,SCALE,NRECSL,ZMAX,LUOT,ICHEK 000
   10 FORMAT(5I10,F10.0,I10,F6.0,2I2)                                  000
      IF(EOF(LUCR))500,501
  501 KI=NZDELT*NFORMT                                                 000
      KN=KI+488                                                        000
      NTRAIL=NRECSL-1                                                  000
C                                                                      000
C     READ THE FIRST PHYSICAL RECORD UNIT FROM THE INPUT TAPE          000
C                                                                      000
      REWIND LUIT                                                      000
      BUFFER IN(LUIT,JP)(INBF(1),INBF(300))                            000
      IF(UNIT(LUIT))11,220,11                                          000
   11 CONTINUE                                                         000
      DECODE(60,20,INBF(1))IRC,IRN,IDTAPE,NS,IRN,IDFILE,NS,IRN,IX,ISL
   20 FORMAT(10I6)                                                     000
      MFT=1                                                              M
      MAX=9                                                              M
      DECODE(60,20,INBF(7))IYMIN,(NZ(M),M=MFT,MAX)                       M
      MFT=10                                                             M
      MAX=19                                                             M
      DO 14 J=13,300,6                                                 000
      DECODE(60,20,INBF(J)) (NZ(M),M=MFT,MAX)                          000
      MAX=MAX+10                                                       000
      MFT=MFT+10                                                       000
   14 CONTINUE                                                         000
      DO 17 I=1,2                                                      MOD
      BUFFER IN(LUIT,JP)(INBF(1),INBF(300))                            MOD
```

```
C CACULATE NUM OF GPS OF 15 ELEV PTS IN SCAN VINE
      NUMSET=(IY2-IY1-1)/7
      IF(NUMSET.LT.1) GO TO 202
      IX15=IY1+1
      DO 201 IT=1,NUMSET
C     SET INDEX FOR 1ST,5TH,10TH,AND15TH POINT OF SET
      IX5=IIX+4
      IX10=IIX+9
      IX15=IIX+14
C     CACULATE EVEN CHANGE
      WRITE(8,601)NZ(IIX),NZ(IX5),NZ(IX10)
  601 FORMAT(3I5)
      CHNG=NZ(IX15)- NZ(IIX)
C     CACULATE DIFF BETWEEN INTERPOLATED AND  ACTUAL
      DIFF1=FLOAT(NZ(IX5))-(FLOAT(NZ(IIX))+1./3.*CHNG)
      DIFF2=FLOAT(NZ(IX10))-(FLOAT(NZ(IIX))+2./3.*CHNG)
C     ADD PTS TO DATA BASE
      SUMSQ=SUMSQ +DIFF1**2+DIFF2**2
      SUMDIF=SUMDIF+DIFF1+DIFF2
      SUMPT=SUMPT+2.0
  201 CONTINUE
      GO TO 200
  202 CHNG =NZ(4)-NZ(1)
      DIFF1=FLOAT(NZ(2))-(FLOAT(NZ(1))+1./2.*CHNG)
      SUMSQ=SUMSQ+DIFF1**2
      SUMDIF=SUMDIF+DIFF1
      SUMPT=SUMPT+2.0
  200 ISKIP=NRECSL*(NZDELT-1)
      KN=K1+494
      ISKIP = NRECSL*(NZDELT-1)
  210 CONTINUE
      STDDEV=SUMSQ/SUMPT-(SUMDIF/SUMPT)**2
      SS=STDDEV**0.5
      WRITE(LUPR,300)STDDEV,SUMPT,NY,NX,NZDELT,SS
  300 FORMAT(1H0,14HTHEVARIANCE IS,F10.1,/24H THE NUMBER OF PTS EQUAL,F7
     -.0,/31H NUMBER OF POINTS  SCAN LINE IS,I5,/31H THE NUMBER OF SCAN
     -LINES EQUAL,I5,/36H THE NUMB OF PTS SKIPED EACH READ IS,I5,/15H TH
     -E STD DEV IS,F10.1)
  220 REWIND LUIT                                                    0004
      GO TO 1
C                                                                    0003
  500 STOP                                                           0009
      END                                                            0004
```

```
      IF (UNIT(LUIT))15,220,15
   15 MFT=500*I-(I+3)
      MAX=MFT+8
      DECODE(60,20,INBF(1)) IRN,(NZ(M),M=MFT,MAX)
      MFT=MFT+9
      MAX=MAX+10
      DO 16 J=7,300,6
      DECODE(60,20,INBF(J)) (NZ(M),M=MFT,MAX)
      MFT=MFT+10
      MAX=MAX+10
   16 CONTINUE
   17 CONTINUE
C
C     CALCULATE THE RESOLUTION OF THE GENERATED MAP AND
C     THE BOUNDARIES OF THE GENERATED RECTANGLE AND THE
C     NUMBER OF SCAN LINES AND NUMBER OF POINTS PER SCAN
C     LINE
C
      NY=(IY2-IY1)/NZDELT+1
      NX=(IX2-IX1)/NZDELT+1
      E=NZDELT*(SCALE*.01*.0254)
      NXY=NY*NX
      YMAX=(NY-1)*E
      XMAX=(NX-1)*E
C
C     WRITE THE BOUNDARY AND SCALE INFORMATION ON THE
C     PRINTER
C
      WRITE(LUPR,40) NS,SCALE,E,NXY,NX,XMAX,YMAX,ZMAX,IX1,IY2,IX2,IY2,
     1IX1,IY1,IX2,IY1
   40 FORMAT(1H ,51H ****************** M A P G E N ******************/
     13H  *,48X,1H*/3H  *,7X,10HSHEET NO.,I6,25X,1H*/3H  *,7X,13HMAP SC
     2ALE  1 ,F10.0,18X,1H*/3H  *,7X,11HRESOLUTION ,F7.2,7H METERS,16X,
     31H*/3H  *,7X,16HTOTAL ELEVATIONS,I6,19X,1H*/3H  *,7X,21HTOTAL NO.
     4SCAN LINES ,I3,17X,1H*/3H  *,7X,6HXMAX  ,
     5F8.1,7H METERS,20X,1H*/3H  *,7X,6HYMAX  ,F8.1,7H METERS,20X,1H*/
     63H  *,7X,6HZMAX  ,F8.1,7H METERS,20X,1H*/3H  *,7X,11HCOORDINATES,
     72H (,I4,1H,,I4,6H)    (,I4,1H,,I4,1H),3X,1H*/3H  *,19X,1H(,I4,1H,,
     8I4,6H)    (,I4,1H,,I4,1H),3X,1H*/3H  *,48X,1H*/52H **************
     9**************************************////)
      IF(ICHEK.GE.2.) GO TO 65
   65 ISKIP=(IX1-IX)*NRECSL-3
C
C     IF SKIP IS EQUAL TO -1 THE FIRST SCAN LINE OF THE
C     INPUT TAPE IS THE BOUNDARY OF THE RECTANGLE
C
      IF(ISKIP.EQ.-1)KN=K1+488
C
C     BEGIN PROCESSING THE INPUT TAPE
C
      IF(IX1.EQ.0) IX1 =1
      DO 210 IXX=IX1,IX2,NZDELT
C
C     IF SKIP IS EQUAL TO ZERO BEGIN PROCESSING THE ELEVATION
C     POINTS IMMEDIATELY. IF SKIP IS EQUAL TO ZERO
C     THE SECOND (NEXT) RECORD IS THE BOUNDARY FOR THE
C     RECTANGLE. IF ISKIP IS GREATER THAN ZERO ONE OR MORE
```

```
C      PHYSICAL RECORD MUST BE SKIPPED TO REACH THE BOUNDARY                  000
C      OF THE RECTANGLE.                                                      000
C      SKIP OVER ISKIP PHYSICAL RECORDS TO THE BOUNDARY OF                    000
C      THE RECTANGLE BEFORE BEGINNING TO PROCESS DATA                         000
C                                                                             000
   73 FORMAT(1X,6HISKIP=,I6)                                                  MOD
      IF(ISKIP)93,90,70                                                       MOD
   70 DO 80 I=1,ISKIP                                                         000
      BUFFER IN(LUIT,JP)(INBF(1),INBF(300))                                   000
      IF(UNIT(LUIT)) 71,220,71                                                000
   71 CONTINUE                                                                000
      DECODE(10,72,INBF(1)) IRC,IFILL                                         000
   72 FORMAT(I6,I4)                                                           000
   80 CONTINUE                                                                000
   90 KN=K1+494                                                               000
      BUFFER IN(LUIT,JP)(INBF(1),INBF(300))                                   000
      IF(UNIT(LUIT))  91,220,91                                               000
   91 CONTINUE
      MFT=1                                                                   MOD
      MAX=5                                                                   MOD
      DECODE(60,20,INBF(1)) IRC,IRN,IX,ISL,IYMIN,(NZ(M),M=MFT,MAX)            MOD
      MFT=6
      MAX=15                                                                  MOD
      DO 92 J=7,300,6
      DECODE(60,20,INBF(J))(NZ(M),M=MFT,MAX)
      MAX=MAX+10
      MFT=MFT+10
   92 CONTINUE
C
C      READ THE FIRST PHYSICAL RECORD OF THE CURRENT SCAN
C      LINE. IF IXX IS NOT EQUAL TO IX AN ERROR HAS OCCURRED
C      AND THE PROGRAM TERMINATED.
C
   93 IF(IXX.EQ.IX) GO TO 100                                                 MOD
      WRITE(LUPR,99)IXX,IX
   99 FORMAT(1H ,4HIXX=,I6,3HIX=,I6)
      GO TO 500
  100 NZL=K1+IY2-IYMIN
      KDEL1=IY1-IYMIN
C
C      READ THE REMAINDER OF THE SCAN LINE
C
      DO 110 I=1,NTRAIL
      BUFFER IN(LUIT,JP)(INBF(1),INBF(300))
      IF(UNIT(LUIT)) 101,220,101
  101 CONTINUE
      MFT =500*I-(I+3)                                                        MOD
      MAX=MFT+8
      DECODE(60,20,INBF(1)) IRN,(NZ(M),M=MFT,MAX)
      MFT=MFT+9
      MAX=MAX+10
      DO 105 J=7,300,6
      DECODE(60,20,INBF(J)) (NZ(M),M=MFT,MAX)
      MFT=MFT+10
      MAX=MAX+10
  105 CONTINUE
  110 CONTINUE
```

APPENDIX C

ORGANIZATION

1. The organization specified in the organizational commons controls the grouping of elements and units as they move. The organization, therefore, is important only to those vehicles that will move during the course of the battle. Normally that will mean that only the attacker's organization will be important. The one exception to this rule is the defending COP. The vehicles that compose the COP must be grouped together in one or more maneuver units so that they will be able to withdraw from the COP in a realistic manner.

2. Before continuing the discussion of organization it is necessary to define some terms as they are used in DYNTACS(X). Individual vehicles (ground or air) are called elements. A section is a tactical grouping of from one to four elements. A platoon is a tactical grouping of either one or two sections. A team can be composed of from one to seven platoons.

3. An additional consideration in DYNTACS(X) is the designation of maneuver units. A maneuver unit is a number (possibly one) of elements that select routes and move in formation as a unified whole. Any level of organization can be designated as a maneuver unit. Once a group of elements has been designated as a maneuver unit, it is not included in any further organizational grouping (e.g., a section level maneuver unit is not assigned to a platoon or team).

4. The level at which maneuver units are assigned is an important one. An improper choice may adversely affect the tactical realism of the battle or unnecessarily increase the model running time. Some aspects of the problem to be considered are as follows:

a. Only the maneuver unit leader selects a route. All other members of a maneuver unit guide on the leader according to the unit and subunit formations directed by the maneuver unit leader. If the maneuver unit is large, then a portion of the unit may be forced to traverse inappropriate terrain in order to maintain the prescribed formation. This may result in a portion of the maneuver unit being unduly exposed to enemy observation and fire or it may mean that a portion of the unit is forced to traverse terrain that blocks all opportunity to establish line of sight. (The multiple paths in the route selection procedure are only used to establish travel time. See AR 69-2A, page 5-44 and appendix F, this document.)

b. The maneuver unit reacts as a whole when any element in the maneuver unit encounters a minefield. The size of the maneuver unit should approximate the unit that would be expected to react to a minefield. (In the

middle ranges the entire maneuver unit will form into a column and plow when reacting to a minefield.)

c. When an element in a maneuver unit is slowed down (traversing difficult terrain, stopping to fire, etc.), the entire maneuver unit reduces its speed until the lagging element is able to catch up. With a large maneuver unit this behavior may significantly reduce the desired rate of advance.

5. All these factors have pointed to a small maneuver unit being desirable. However, the following considerations indicate the desirability of large maneuver units:

a. Each maneuver unit selects its route with respect to its input routes and the enemy situation. It does not consider the behavior of other friendly units during the decision process. With a number of small units, it is possible to have several maneuver units attempt to use the same piece of desirable terrain simultaneously. This could produce a tactically unrealistic massing of the attackers during the advance.

b. Each maneuver unit must execute the route selection routines. These routines are lengthy and time consuming. The greater the number of maneuver units, the longer the running time for a given number of elements. This will have obvious cost implications where computer time is being purchased.

6. After an analysis of these factors, the attacking maneuver units were established as platoon size units for the HELLFIRE and CLGP COEAs. The decision may vary based on the scenario and terrain used for any given study.

7. Once the decision about the size of the maneuver unit has been made, one can then prepare a work sheet prior to coding the organizational commons. The following points should be helpful in organizing a worksheet:

a. Blue elements must be listed first. This holds whether Blue is attacking or defending.

b. Elements are numbered consecutively from section to section. Sections are numbered consecutively from platoon to platoon, etc.

c. The consecutive numbering rule applies even when progressing from Blue to Red elements.

d. Each helicopter must be assigned to its own section, platoon, team, and maneuver unit.

8. A portion of a completed worksheet is provided in figure C-1. Although not required for the organizational commons, the type of vehicle and positions of the elements are included because this information is helpful when preparing

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A REVIEW OF THE COMPILATION OF THE DYNTACS(X) DATA BASE FOR THE--ETC(U)
JUN 76 D K HUGUS
UNCLASSIFIED CACDA-TR-9-76 NL

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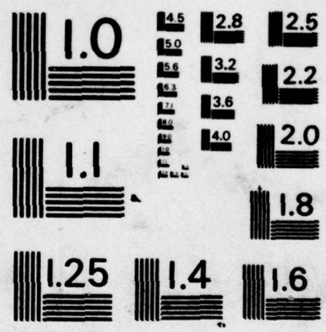

1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

Element	Section	Platoon	Team	Manu Unit	Type	Location COP	Location FEBA/ATK
1	1	1	-	1	M60		
2	1	1	-	1	M60		
3	2	1	-	1	TOW		
4	2	1	-	1	TOW		
5	2	1	-	1	APC		
6	3	-	-	2	TOW		
7	3	-	-	2	TOW		
8	3	-	-	2	TOW		
9	3	-	-	2	TOW		
10	4	2	1	3	APC		
11	4	2	1	3	APC		
12	5	2	1	3	APC		
13	5	2	1	3	APC		
14	6	3	1	3	APC		
15	6	3	1	3	APC		
16	7	3	1	3	APC		
17	7	3	1	3	APC		
.	.	.	.	.	.		
.	.	.	.	.	.		
.	.	.	.	.	.		
29	14	26	8	11	AAH		
30	15	27	9	12	AAH		
31	11	8	-	6	T62		
32	11	8	-	6	T62		
33	11	8	-	6	T62		
34	12	9	-	7	T62		
.	.	.	.	.	.		
.	.	.	.	.	.		
.	.	.	.	.	.		

Figure C-I. Example of a DYNTACS(X) Organization

other commons and general reference. Another worksheet that has been found to be helpful is displayed in figure C-2. This worksheet merely organizes and presents general descriptive information about the vehicles to be played. Because the two worksheets identify individual elements and codes as pertaining to particular weapon systems, these worksheets are normally classified.

9. A run design will often contain a requirement to modify the number of weapons in a force or the type of weapons in a force. For instance, a tank study might require a base case with the present tank and another set of runs with the proposed tank design. In these cases it may be convenient to provide a separate weapon code to each tank and include the data describing all tanks in a single data base. When one desires to change the type of tank being played, only a single common (LWCOD) would need to be changed to reflect the change of weapons systems. In those cases where the number of weapons is varied, one should include the maximum number of weapons to be played in the original data base. When less than the maximum number are to be played, excess weapons can be "killed" before the battle starts by entering a 4 in the appropriate LIMNAT storage area. This will prohibit the designated weapon from taking part in any phase of the battle. By making the data base flexible by including all types of weapons and the maximum number of weapons to be played one insures that the run design will be executed smoothly. This procedure avoids delays that would be experienced if the data base had to be modified for each change in force structure required by the run design.

10. The assignment of elements to radio nets is independent of the tactical assignment of those elements. Although they are not dependent on the organization, the radio nets usually follow the tactical organization of respective forces. (The one exception to this general rule concerns the elements on the COP. Since the COP is normally a combined arms temporary tactical grouping, the elements in the COP will not normally be assigned to the same platoon radio net based on the tactical organization. However, tactical integrity requires that the elements on the COP communicate. Since there is no mechanism that allows an element to switch radio nets, except when a casualty occurs, once a radio net is assigned it cannot be changed. Although it is unusual, to have tanks and APC on the same radio net, it appears that an accurate portrayal of the communications between COP elements is more important than having all tanks on the same platoon net on the FEBA. Of course, this problem could be eliminated by a modification of subroutine HAZAM which would reassign the surviving COP elements to a new radio net upon return to the FEBA. But until such a modification takes place, it seems that it is appropriate to deviate from the tactical organization and assign the COP elements to the same platoon net.) Therefore, it is generally helpful to assign elements to radio nets soon after the tactical disposition has been determined. Each element is assigned to one or more of the following: platoon, company, or battalion nets. All elements are normally assigned to a platoon net. Platoon leaders are usually assigned to a company net and company commanders to the battalion net. It is important to note that the communications model assumes that these are two battalion nets. Even if one side is composed of a company or less, a net must be allocated as a battalion net for that side.

Vehicle Type	Ammo Type	Basic Load	Weapon Code	Weapon* System Code	Mobility Code
TOW	1 (Missile)	15	1	2	1
M60	1 (50 Cal MG)	500	2	1	2
	2 (HEP)	10			
	3 (HEAT)	15			
	4 (APDS)	25			
Dragon	1 (Missile)	5	3	3	-
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.

Figure C-2. Weapon Characteristics Assignment

*The weapon and mobility codes are arbitrarily assigned. Order is not important. However, there is some logic in the model that assumes the weapon system codes are assigned according to the following order: 1 for armored vehicles, 2 for APC, and 3 for crew served weapon.

Element	Weapon	Job	Platoon Net	Company Net	Battalion Net
1	M60	Plt Ldr	1	37	--
2	M60	--	1	--	--
3	M60	--	1	--	--
4	APC	Plt Ldr	2	37	--
5	APC	CO	2	37	42
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
30	ADH	Plt Ldr	6	38	--
31	T62	Plt Ldr	7	39	--
32	T62	--	7	--	--
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
120	T62	--	36	--	--

Figure C-3. Assignment of Radio Nets

11. Each net is assigned a number in a single numbering sequence. The first Blue platoon net is set number one, the second two, etc. The first Red platoon net is one greater than the last Blue platoon net. The first Blue company net is one greater than the last Red platoon net. Fire support nets are not included in this net assignment. The model itself sets up the fire support nets based on the assignment of FOs to artillery units. A sample net assignment is depicted in figure C-3.

APPENDIX D

LOCATION OF DEFENSIVE WEAPONS

1. In general, a map analysis is a tenuous basis for selecting weapon locations. Small convolutions or undulations in the ground, which do not show up on a map, can have a major impact on the visibility and fields of fire that are available to a weapon. These real life problems are compounded when a map analysis is used to place weapons on a computer representation of a piece of terrain. Small shifts in the location and height of hilltop and ridge crests caused by the computer representation can turn an excellent position into a worthless reverse slope location. Just as the military commander needs to walk the terrain when weapons are emplaced, the military tactician needs to "see" the results of his weapon location selection for a model run.

2. The tool that has been developed to allow a reasonable selection of defensive positions is the line-of-sight map. A computer program has been written that uses the DYNTACS(X) terrain input and line-of-sight routines to produce a representation of the line-of-sight available from a given location. A description of the input requirements and output of the line-of-sight program is provided at annex D-I. The program itself is at inclosure D-I-a. An example of input data is at inclosure D-I-b.

3. Normally, each study has a group of tactical experts designated to resolve questions of a tactical nature. If the study directive or other document has not tasked a specific group or agency to provide tactical input, the study agency should consider the formation of such a group. It is inadvisable to allow the person who is preparing the input data to exercise his individual judgment on tactical questions.

4. The group of tactical experts should select the initial positions for the weapons. It is important that during the selection the tactical group be restricted to the level of knowledge that the tactical commander would normally have. Perhaps the only information provided will be the FEBA trace and the general direction of the attack. When only this information is known, the tactical planners are likely to produce a more realistic tactical disposition than they would if the actual attack routes were known.

5. After the initial selection of positions, the person charged with the data preparation will run the line-of-sight program to produce the visibility maps for these positions. Normally, not all of the initially selected positions will be acceptable. This will require additional runs of the line-of-sight program using alternate positions. The terrain map and environmental overlays discussed in annex A-II will be useful in selecting these alternate positions. The contour plot produced by the MAPLOT program will give a better indication than a topographical map of how the computer represents terrain. When the vegetation overlay is superimposed

over the MAPLOT map, potential blocks to line of sight can be identified and obviously unacceptable positions can be eliminated without requiring a line-of-sight map. Judicious use of these two computer-produced tools will aid in the identification of acceptable positions for defensive weapons. Sometimes it will become necessary to make major adjustments to the initially selected positions in order to find an acceptable position for a weapon. After the final positions have been tentatively selected by the data base personnel, the tactical group should approve the final positioning. In this way, final weapon positions will be checked for compliance with present tactical doctrine.

6. In addition to the location of the weapons, two other factors must be set for the defenders in the initial data: the degree of cover (shielding by the earth) and distance to the nearest clump of vegetation. The distance to the nearest clump of vegetation has implications in the detection routine. The closer the weapon is to a clump, the lower the probability that it will be detected. However, this number is changed each time an attacker changes position with respect to a defender, so the initial value has no lasting impact. The degree of cover is more important in its implications. It is possible to simulate a dug-in weapon's position by setting the element's microterrain (common EMICR) value equal to a negative number. The magnitude of the number indicates the depth of the dug-in position. If the EMICR value is set equal to the hull height, a hull defilade position is depicted. The EMICR value will change only when the vehicle itself moves. Therefore, the degree of cover for a defender will be largely controlled by the initial input value. Hit probabilities in DYNTACS(X) are very sensitive to the degree of cover provided by the terrain. The selection of the EMICR value should be appropriate when considering the time the defending force has had to prepare the positions.

7. One cautionary note should be sounded here. The play of camouflage is a difficult task. There does not appear to be a sufficiently comprehensive field experiment to allow a thorough analysis of the effects of camouflage. In this absence of empirical data it is tempting to generate an ad hoc procedure that has some intuitive appeal. Although there can be no objection to this philosophical approach, one must take care to insure that the intuitive approach actually has the desired effect. One group of users of DYNTACS(X) attempted to play cmaouflage by placing a vegetation feature around each defending weapon. Although this has an intuitive appeal, the effects of this approach were more far reaching than the effects camouflage could reasonably have. The model, in this approach, would consider each defending weapon a completely concealed weapon to all attackers, with the following consequences:

a. The probability of visual detection by any attacker is zero regardless of range.

b. Attackers could detect the presence of a defending weapon only by observing the firing signature.

c. When firing at a defender, the attacker's hit probability was severely degraded because of the lack of visual observation of the firing vehicle.

d. The attackers could only fire at a defender after the defender itself had fired because of the requirement to observe a firing signature.

8. The elimination of all possibility of visual detection, the decreased rate of firing for the attackers, and the significantly reduced accuracy of attacker fire all go far beyond the effects of camouflage. Therefore, this particular procedure for playing camouflage is not recommended. Because of these far reaching effects of vegetation surrounding a defending weapon, serious consideration should be given before a defender is placed inside a vegetation feature.

ANNEX D-I

LINE-OF-SIGHT PROGRAM

1. The line-of-sight (LOS) program is described visually in figure D-I-2. The description in figure D-I-1 is keyed to the cards in that figure.

Card Number	Description
1	Job card.
2	Execute card. Either G or H level compilers may be used. All unnecessary compiler output is suppressed. The TIME parameter default value should not be used. As a rule, 1 minute execute time should be allowed for each LOS map produced..
3	Inputs the source program (assumed to be stored on disc) for compilation and loading.
4	Identifies the object module of the terrain features (see FEATUR program, annex A-III).
5	Identifies the object module of the elevation data (see annex A-III).
6-8	Inputs the object modules to the loader
9	Identifies the beginning of the data stream.
11-13	Data cards (see below).
14	End of data card.
15	End of file card

Description of LOS Input Data

Figure D-I-1

2. The initial data card defines the terrain area of interest and determines certain program parameters. These parameters remain in effect until a -1.0 is read in columns 1-4. Then new parameters are defined for additional positions or the program is terminated. The input format for the initial data card is shown in figure D-I-3. The following pertain to the variables defined by the first card:

a. XMIN. The X coordinate of the left boundary of the terrain area of interest; i.e., the left boundary of the printed LOS map.

b. XMAX. The X coordinate of the right boundary of the printed LOS map. XMIN and XMAX must be defined such that if Limit is the largest possible X

coordinate on the defined terrain area:

$$0 \le XMIN < XMAX \le Limit.$$

c. YMIN. The Y coordinate of the lower boundary of the printed LOS map.

d. YMAX. The Y coordinate of the upper boundary of the printed LOS map. YMIN and YMAX must be defined such that if Limit is the largest possible Y coordinate on the defined terrain area:

$$0 \le YMIN < YMAX \le Limit$$

e. RANGE. The range from the observer beyond which LOS will not be computed.

f. MAX. The number of copies of the LOS map to be printed.

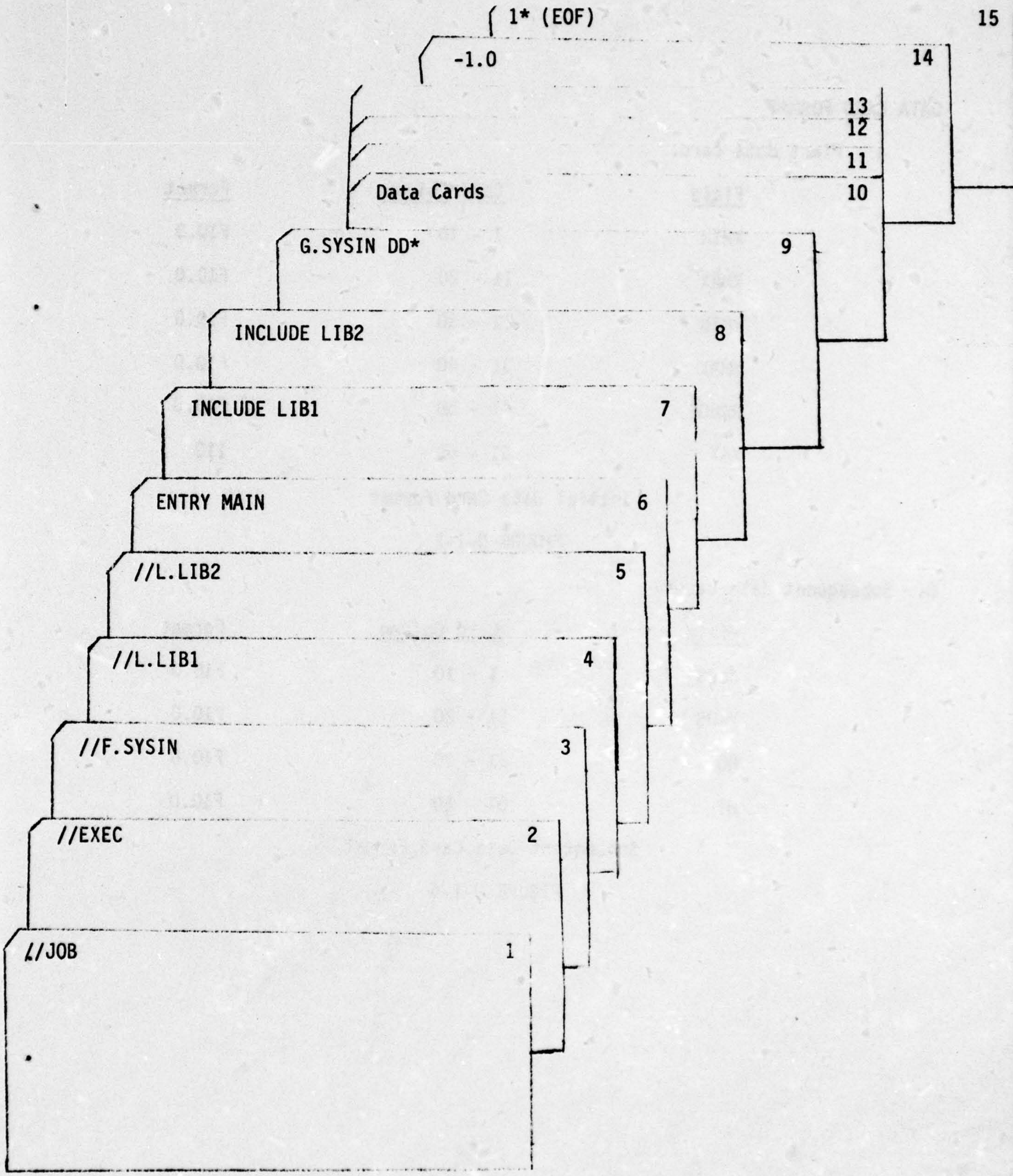
3. Subsequent data cards are used to define values for an individual LOS map. The card format for subsequent data cards is shown in figure D-I-4. The following pertain to the variables contained on subsequent data cards:

a. XLOS. The X coordinate of the observer.

b. YLOS. The Y coordinate of the observer.

c. HO. The height of the observer's eyeball (should be vehicle height plus the EMICR value) above the ground.

d. HT. The maximum height of the observed vehicle.



Schematic of LOS Input Deck

FIGURE D-I-2

DATA CARD FORMAT

a. First data card.

Field	Card Column	Format
XMIN	1 - 10	F10.0
XMAX	11 - 20	F10.0
YMIN	21 - 30	F10.0
YMAX	31 - 40	F10.0
RANGE	41 - 50	F10.0
MAX	51 - 60	I10

Initial Data Card Format

FIGURE D-I-3

b. Subsequent data cards.

Field	Card Column	Format
XLOS	1 - 10	F10.0
YLOS	11 - 20	F10.0
HO	21 - 30	F10.0
HT	31 - 40	F10.0

Subsequent Data Card Format

FIGURE D-I-4

INCLOSURE D-I-a

LINE OF SIGHT PROGRAM

```
//CACDA21 JOB (XXXXXXXX,C,U,N),'GARRETT'
// EXEC FHLG,PARM='NOSOURCE,NOMAP,NOID',TIME=(20,59)
//F.SYSIN DD *
      BLOCK DATA
      COMMON / DCON / DCON(6,10)
      DATA DCON(1,1) /0.0/
      DATA DCON(1,2) /0.0/
      DATA DCON(1,3) /0.0/
      DATA DCON(1,4) /0.006/
      DATA DCON(1,5) /0.006/
      DATA DCON(1,6) /0.0125/
      DATA DCON(1,7) /0.0125/
      DATA DCON(1,8) /0.04/
      DATA DCON(1,9) /0.005/
      DATA DCON(1,10) /0.04/
      DATA DCON(2,1) /100.0/
      DATA DCON(2,2) /100.0/
      DATA DCON(2,3) /100.0/
      DATA DCON(2,4) /75.0/
      DATA DCON(2,5) /75.0/
      DATA DCON(2,6) /50.0/
      DATA DCON(2,7) /50.0/
      DATA DCON(2,8) /25.0/
      DATA DCON(2,9) /500.0/
      DATA DCON(2,10) /500.0/
      DATA DCON(3,1) /0.0/
      DATA DCON(3,2) /0.0/
      DATA DCON(3,3) /0.0/
      DATA DCON(3,4) /0.0/
      DATA DCON(3,5) /0.0/
      DATA DCON(3,6) /0.01/
      DATA DCON(3,7) /0.01/
      DATA DCON(3,8) /0.025/
      DATA DCON(3,9) /1.0/
      DATA DCON(3,10) /1.0/
      DATA DCON(4,1) /3.0/
      DATA DCON(4,2) /3.0/
      DATA DCON(4,3) /3.0/
      DATA DCON(4,4) /10.0/
      DATA DCON(4,5) /10.0/
      DATA DCON(4,6) /10.0/
      DATA DCON(4,7) /10.0/
      DATA DCON(4,8) /15.0/
      DATA DCON(4,9) /7.5/
      DATA DCON(4,10) /7.5/
      DATA DCON(5,1) /1.0/
      DATA DCON(5,2) /1.0/
      DATA DCON(5,3) /1.0/
      DATA DCON(5,4) /0.394/
      DATA DCON(5,5) /0.394/
      DATA DCON(5,6) /0.472/
      DATA DCON(5,7) /0.472/
      DATA DCON(5,8) /0.135/
      DATA DCON(5,9) /0.0/
      DATA DCON(5,10) /0.0/
      DATA DCON(6,1) /0.1/
      DATA DCON(6,2) /0.1/
      DATA DCON(6,3) /0.1/
      DATA DCON(6,4) /0.9/
      DATA DCON(6,5) /0.9/
      DATA DCON(6,6) /0.9/
      DATA DCON(6,7) /0.9/
      DATA DCON(6,8) /0.9/
```

```
      DATA DCON(5,9) /0.9/
      DATA DCON(6,10)/0.9/
      END
      DIMENSION TITLE(24),IH(11)
      REAL LOSCMP
      COMMON/FOREST/HTREE
      DATA IPLS /4H+   /
      DATA ISTAR /4H$   /
      DATA TITLE(1) /4HLEGE/
      DATA TITLE(2) /4HND- /
      DATA TITLE(3) /4H    /
      DATA TITLE(4) /4H . =/
      DATA TITLE(5) /4H NO /
      DATA TITLE(6) /4HLOS,/
      DATA TITLE(7) /4H    /
      DATA TITLE(8) /4H    /
      DATA TITLE(9) /4HX= L/
      DATA TITLE(10) /4HOS  /
      DATA TITLE(11) /4H    /
      DATA TITLE(12) /4H 1,2/
      DATA TITLE(13) /4H,.../
      DATA TITLE(14) /4H,9 T/
      DATA TITLE(15) /4HIMES/
      DATA TITLE(16) /4H 10 /
      DATA TITLE(17) /4H= PE/
      DATA TITLE(18) /4HRCEN/
      DATA TITLE(19) /4HT OF/
      DATA TITLE(20) /4H HT /
      DATA TITLE(21) /4HVISI/
      DATA TITLE(22) /4HBLE /
      DATA IH(1) /1H./
      DATA IH(2) /1H1/
      DATA IH(3) /1H2/
      DATA IH(4) /1H3/
      DATA IH(5) /1H4/
      DATA IH(6) /1H5/
      DATA IH(7) /1H6/
      DATA IH(8) /1H7/
      DATA IH(9) /1H8/
      DATA IH(10) /1H9/
      DATA IH(11) /1HX/
      HTREE=10.0
      PTIME=0
      READ(5,1000) XMIN,XMAX,YMIN,YMAX,RANGE,MAX
 1000 FORMAT(5F10.0,I10)
      DX=XMAX-XMIN
      DY=YMAX-YMIN
      RESX=DX/100.0
      RESY=DY/50.0
   10 READ(5,1010) XLOS,YLOS,HO,HT
 1010 FORMAT(4F10.0)
      IF(XLOS.LT.0.) STOP
      CALL PLOT1 (XMIN,XMAX,YMIN,YMAX,IPLS)
      YPT=YMAX
      COUNT=0.
      DO 40 J=1,51
      XPT=XMIN
      DO 30 I=1,101
      IF (RANGE**2 .LT. (XLOS-XPT)**2+(YLOS-YPT)**2) GO TO 20
      COUNT=COUNT+1.
      IST=LOSCMP(XLOS,YLOS,XPT,YPT,HO,HT,0.0,0,.FALSE.)*10.0+0.5
      ISST=10-IST+1
      IND=IH(ISST)
      CALL PLOT2(XPT,YPT,1,IND)
   20 XPT=XPT+RESX
   30 CONTINUE
```

```
      YPI=YPI-RESY
   40 CONTINUE
      CALL PLOT2(XLOS,YLOS,1,ISTAR)
      DO 50 I=1,MAX
      CALL PLOT3 (TITLE,22)
      WRITE(6,1020)XLOS,YLOS
 1020 FORMAT(15X,33H$ IS OBSERVER, COORDINATES ARE X=,F6.0,5X,2HY=,F6.0)
      WRITE(6,1030)HO,HT,RANGE,TIME,PTIME
 1030 FORMAT(15X,3HHO=,F7.2,5X,3HHT=,F7.2,5X,6HRANGE=,F6.0,5X,5HTIME=,
     1F5.2,9H MINUTES ,2H (,F5.2,18H MS. PER LOS CALL) )
      WRITE(6,1040)
 1040 FORMAT (1H1)
   50 CONTINUE
      GO TO 10
      END
      SUBROUTINE PLOT1(XMIN,XMAX,YMIN,YMAX,IND)
      COMMON/XAXIS/XAXIS(6)
      COMMON/YAXIS/YAXIS(6)
      COMMON/PLTARY/PLTARY(53,104)
      COMMON/ALSO/DELTX,DELTY,EFTX,DWRY
      INTEGER PLTARY,BLANKS
      DATA BLANKS/4H    /
      XAXIS(1)=XMIN
      YAXIS(1)=YMAX
      X=XMAX-XMIN
      Y=YMIN-YMAX
      DO 10 I=2,6
      XAXIS(I)=XAXIS(I-1)+X/5.0
   10 YAXIS(I)=YAXIS(I-1)+Y/5.0
      DELTX=X/100.0
      DELTY=Y/50.0
      EFTX=XMIN-DELTX
      DWRY=YMAX-DELTY
      DO 20 I=1,104
      DO 20 J=1,53
   20 PLTARY(J,I)=BLANKS
      DO 40 I=1,104
      PLTARY(1,I)=IND
   40 PLTARY(53,I)=IND
      DO 50 I=2,52
      PLTARY(I,1)=IND
   50 PLTARY(I,104)=IND
      RETURN
      END
      SUBROUTINE PLOT2(XVAL,YVAL,NUM,IND)
      COMMON/PLTARY/PLTARY(53,104)
      INTEGER PLTARY
      COMMON/ALSO/DELTX,DELTY,EFTX,DWRY
      DIMENSION XVAL(1),YVAL(1)
      IF(NUM.LT.1)RETURN
      DO 10 I=1,NUM
      J=(XVAL(I)-EFTX)/DELTX+1.5
      IF(J.LT.1) J=1
      IF(J.GT.104) J=104
      K=(YVAL(I)-DWRY)/DELTY+1.5
      IF(K.LT.1) K=1
      IF(K.GT.53) K=53
   10 PLTARY(K,J)=IND
      RETURN
      END
      SUBROUTINE PLOT3(TITLE,N)
      COMMON/XAXIS/XAXIS(6)
      COMMON/YAXIS/YAXIS(6)
      COMMON/PLTARY/PLTARY(53,104)
      INTEGER PLTARY
      DIMENSION TITLE(N)
```

```
      WRITE(6,100) (TITLE(I),I=1,N)
  100 FORMAT(11X,22A4)
      WRITE(6,110)
  110 FORMAT(1H )
      DO 50 I=1,53
      J=I/10
      IF (I-J*10 .EQ. 2) GO TO 40
      WRITE(6,140)(PLTARY(I,J),J=1,104)
  140 FORMAT(17X,104A1)
      GO TO 50
   40 WRITE(6,120) YAXIS(J+1),(PLTARY(I,J),J=1,104)
  120 FORMAT(2X,F13.0,2H -,104A1)
   50 CONTINUE
      WRITE(6,130) (XAXIS(I),I=1,6)
  130 FORMAT(6(19X,1H1)/6X,5(F14.0,6X),F14.0/)
      RETURN
      END
      REAL FUNCTION LOSCMP (XA,YA,XD,YD,HA,HD,HM,JWCOD,BOOL)
C
C     COMPUTES FRACTION OF HD (LOCATED AT (XD,YD)) WHICH IS COVERED
C      WHEN OBSERVED FROM A HEIGHT OF HA ABOVE THE MACRO-TERRAIN AT
C      (XA,YA).
C
C     LOSCOMP=0.0 IMPLIES NO OBSTRUCTION OF LOS
C     LOSCOMP=1.0 IMPLIES COMPLETE OBSTRUCTION
C     XA,YA = COORDINATES OF FIRST POINT
C     XD,YD = COORDINATES OF SECOND POINT
C     HA = HEIGHT OF FIRST + MICRO-TERRAIN
C     HD = HEIGHT OF SECOND +MICRO TERRAIN (HM)
C     HM = MICRO TERRAIN OF SECOND
C     BOOL =.TRUE. FOR DELCOV,.FALSE. FOR OTHERWISE
      COMMON/PKOV/PKOV(1)
      COMMON/FOREST/HTREE
      DIMENSION BLOCK(11)
      DIMENSION R (3),DR(3)
      EQUIVALENCE (RD,BLOCK(1))
      EQUIVALENCE (BX,BLOCK(2))
      EQUIVALENCE (BY,BLOCK(3))
      EQUIVALENCE (DX,BLOCK(4))
      EQUIVALENCE (DY,BLOCK(5))
      EQUIVALENCE (R (1),BLOCK(6))
      EQUIVALENCE (DR(1),BLOCK(9))
C *** SET TANLIM IN CASE RD = 0
      EQUIVALENCE (TANLIM,ELVD)
      LOGICAL BOOL
      ELVA= ELVATE(XA,YA)+HA
      ELVD= ELVATE(XD,YD)
C     SETUP BLOCK
      CALL PDPSET(XA,YA,XD,YD,BLOCK)
      IF(RD .NE. 0.0) TANLIM = (ELVD + HD - ELVA)/RD
      TANMAX=-1000000.
      DO 20 I=1,3
      RP=R(I)
      GOTO  12
   10 CONTINUE
      RP=RP+DR(I)
   12 IF(RP.GE.RD) GOTO 20
      XP=DX*RP+BX
      YP=DY*RP+BY
      HLOS=ELVATE(XP,YP)-ELVA
      TANMRP=TANMAX*RP
      IF(HLOS+HTREE.LE.TANMRP) GOTO 10
      HLOS=HLOS+TREES(XP,YP)
      IF(HLOS.LE.TANMRP) GOTO 10
      TANMAX=HLOS/RP
      IF (TANMAX.LT.TANLIM .OR. BOOL) GO TO 10
```

```
      LOSCMP =1.
      RETURN
   20 CONTINUE
      TEMP=((TANLIM-TANMAX)*RD)/(HD-HM)
      IF(BOOL) GOTO 30
      IF(TEMP .GT. 1.0) TEMP=1.0
      LOSCMP =1.0-TEMP
      RETURN
   30 LOSCMP =PKOV(JWCOD)-TEMP*(HD-HM)
      RETURN
      END
      SUBROUTINE PDPGET(BLOCK,X,Y,RT)
C
C     COMPUTE THE NEXT PLANE DEPARTURE POINT
C
      DIMENSION BLOCK(11)
C     SEE PDPSET FOR BLOCK SETUP
C     FIND NEXT POINT
      I=6
      IF(BLOCK(7)-BLOCK(6)) 1020,1010,1030
 1010 BLOCK(6)=BLOCK(6)+BLOCK(9)
 1020 I=7
 1030 IF(BLOCK(8)-BLOCK(I))   1050,1040,1060
 1040 BLOCK(I)   =BLOCK(I+3)+BLOCK(I)
 1050 I=8
 1060 CONTINUE
      R=BLOCK(I)
      RT=R
      X=BLOCK(4)*R+BLOCK(2)
      Y=BLOCK(5)*R+BLOCK(3)
      BLOCK(I)   =R+BLOCK(I+3)
      RETURN
      END
      SUBROUTINE PDPSET(XA,YA,XD,YD,BLOCK)
C
C     SETUP BLOCK FOR COMPUTATION OF PLANE DEPARTURE POINTS
C        BETWEEN XA,YA AND XD,YD.
      COMMON/MAPCOM/E
      DIMENSION BLOCK(11)
      DIMENSION DR(3),R(3),B(3),D(3)
      EQUIVALENCE(BX,B(1)),(BY,B(2)),(BR,B(3))
      EQUIVALENCE (DX,D(1)),(DY,D(2)),(DT,D(3))
      BX=XA
      BY=YA
      BR=BX+BY
C     COMPUTE DELTAS
      DX=XD-BX
      DY=YD-BY
      RD=SQRT(DX**2+DY**2)
      IF(RD.EQ.0.) GOTO 3
      DX=DX/RD
      DY=DY/RD
    3 CONTINUE
      DT=DX+DY
C     DEFINE BLOCK EQUIVALENCE
      BLOCK(1)=RD
      BLOCK(2)=BX
      BLOCK(3)=BY
      BLOCK(4)=DX
      BLOCK(5)=DY
      DO 100 I=1,3
C     COMPUTE DR(I) AND INITIAL R(I)
C     I=1 CORRESPONDS TO VERTICAL
C     I=2 CORRESPONDS TO HORIZONTAL
C     I=3 CORRESPONDS TO DIAGONAL
      IF (D(I)) 10,20,30
```

```
10 ONE=0.
   GO TO 40
20 R(I)=RD+1.
   GOTO 50
30 ONE=1.
40 DR(I)=ABS(E/D(I))
   R(I)=(E*(AINT(B(I)/E)+ONE)-B(I))/D(I)
   IF (R(I).EQ.0.) R(I)=DR(I)
50 CONTINUE
C     DEFINE BLOCK EQUIVALENCE
   BLOCK(I+5)=R(I)
   BLOCK(I+8)=DR(I)
100 CONTINUE
   RETURN
   END
   FUNCTION TREES(X,Y)
C
C     TREES.COMPUTES THE HEIGHT OF TREES AT (X,Y)
C
   COMMON/TDDATA/ NMBC,NMBP,NUMFC,NUMFP
   COMMON/TDP/ TDP(7,1)
   COMMON/TDC/ TDC(3,1)
C     CHECK PARALLELAGRAMS
C     PARA, ARE SAME AS LCTF
C
   LIMITP = 251
   HC = 0.0
   JCODE = 0
   IF (NUMFP.EQ.0) GO TO 20
   DO 10 J=1,NUMFP
   I=ITDFP(J)
   IF (X.LT.TDP(1,I))GO TO 20
   XINTCT=X-TDP(5,I)*Y
   IF (XINTCT.LT.TDP(6,I) .OR. XINTCT.GT.TDP(7,I)) GO TO 10
   YINTCT=Y-TDP(2,I)*X
   IF (YINTCT.LT.TDP(3,I).OR.YINTCT.GT.TDP(4,I)) GO TO 10
   ISUB = TD(1,I) + 1
   IF(DCON(4,ISUB).GT.HC) HC = DCON(4,ISUB)
   JCODE = 1
10 CONTINUE
20 CONTINUE
C
C     CHECK CIRCLES
C     CIRCLES ARE THE SAME AS LCTF
C
   IF (NUMFC.EQ.0) GO TO 40
   DO 30 J=1,NUMFC
   K = ITDFC(J)
   I = K + LIMITP
   XT = X - TDC(1,K)
   IF(XT.GT.TDC(3,K)) GO TO 30
   IF(XT.LT.-TDC(3,K)) GO TO 40
   IF(XT**2+(Y-TDC(2,K))**2.LE.TDC(3,K)**2) GO TO 60
   GO TO 30
60 ISUB = TD(1,I) + 1
   IF(DCON(4,ISUB).GT.HC) HC = DCON(4,ISUB)
   JCODE = 1
30 CONTINUE
40 IF(JCODE.EQ.1) GO TO 50
   TREES=0.
   RETURN
50 TREES = HC
   RETURN
   END
   FUNCTION ELVATE(X,Y)
   INTEGER*2 MAP
```

```
      COMMON/MAPCOM/E,NY,XMAX,YMAX,ZMAX,MAP(1)
      WX=X/E
      WY=Y/E
      IX=WX
      IY=WY
      RX=WX-FLOAT(IX)
      RY=WY-FLOAT(IY)
      IF (RX+RY .LE. 1.0) GO TO 100
      RX=1.-RX
      RY=1.-RY
      IA=(IX+1)*NY+IY+2
      IB=IA-1
      IC=IA-NY
      GOTO 200
  100 CONTINUE
      IA=IX*NY+IY+1
      IB=IA+1
      IC=IA+NY
  200 CONTINUE
      A=MAP(IA)
C     ELVATE=A+RX*(FLOAT(MAP(IC))-A)+RY*(FLOAT(MAP(IB))-A)
      B=MAP(IB)
      C=MAP(IC)
      ELVATE=A+RX*(C-A)+RY*(B-A)
      RETURN
      END
//L.LIB1 DD DSN=NAME.COEA.DECENT.FEATURES,DISP=SHR
//L.LIB2 DD DSN=NAME.COEA.DECENT.ELEVATON,DISP=SHR
      ENTRY MAIN
      INCLUDE LIB1
      INCLUDE LIB2
//G.SYSIN DD *
9450.     14586.     0.        3000.     5000.                        1
9550.      2788.     1.        2.84
9575.       900.     1.        2.84
9586.       348.     1.        2.84
-1.0
/*
```

APPENDIX E

FORMATIONS

The establishment of possible formations for maneuver units is discussed on pages 5-55 to 5-71, Report AR 69-2A, The Tank Weapon System, Systems Research Group, October 1969. The Discussion contained therein generally provides sufficient information to allow the appropriate data commons to be initialized. A few points, however, should be emphasized in order to avoid confusion or unnecessary problems during debug operations:

a. Reference page 5-57, the organization related programming has been modified to allow section size maneuver units.

b. Reference page 5-57. Although there is usually no advantage to having a team with only one platoon, a team can be limited to a single platoon. (Recall that helicopters require a one element section, a one section platoon, a one platoon team, and an individual maneuver unit.)

c. Care should be taken to insure that the weapon locations within a formation will remain tactically reasonable after casualties have been sustained. Thorough understanding of the renumbering system used is important. Special note should be taken of the difference between the renumbering system used for elements and that used for platoons.

d. The threat situation chart (table 5-2, page 5-70) has been expanded to include a tenth situation, employment of a line charge.

e. The formation selected for threat situation nine, traversing a minefield, must insure that the vehicle with the plow is the lead vehicle. An abnormal termination will result if this is not done. The plow vehicle must continue to be the lead element even when casualties have occurred within the plowing vehicle's unit.

APPENDIX F

ROUTE SELECTION

1. The key to the route selection process is the tactical difficulty matrix. The construction of this matrix determines the route that is finally selected. The basic building blocks for the tactical difficulty matrix are the vehicle mobility and the difficulties and ranges assigned to enemy weapons. Since the vehicle mobility is composed of technical information, as long as the data are carefully collected, one can be reasonably sure that the mobility contribution to the composition of the tactical difficulty matrix will be accurate. However, the difficulties and estimated ranges associated with the enemy weapons are more subjective in nature and, hence, require consideration.

2. When determining the difficulty of moving from point I to point J in the route selection matrix, the sum of the weapon difficulties for point J are multiplied by the time required to move from point I to J. This procedure suggests that the difficulties are analogous to attrition rates, and the route selection procedure minimizes attrition. One can approximate this concept by equating the difficulty of each weapon with its probability of kill against a given target under prescribed conditions. This will allow the characteristics of each weapon to determine its ranking among the defense weapons.

3. This procedure does have its drawbacks. The probability of kill may vary significantly from opening fire range to the assault range. The probability of kill for each weapon must be hand calculated from the probability of hit and probability of kill given a hit. (The probability of hit is hand calculated using the conceptual approach embodied in the equation in figure 8-4, page 8-19, Report AR 69-2B, The Tank Weapon System, Systems Research Group, September 1960; the probability of kill is extracted from the PKTNK or TPMKH common.) One must be willing to make some assumptions when defining the standard conditions (e.g., the given target will be a T-62 tank, 15 percent covered, moving at 4.5 meters per second at an aspect angle of 30^{o}); and conceptually some important factors in an attrition rate calculation are missing (e.g., rate of fire, detection capability, length of exposure, etc.). However, even acknowledging that these difficulties exist, this procedure is probably preferable to having some person or group guess at the relative difficulties.

4. As specified in the documentation (page 5-30, Report AR 69-2A, The Tank Weapon System, Systems Research Group, September 1960) a weapons difficulty is assigned to those points in the route selection matrix that are within the enemy commander's estimate of that weapon's range. The enemy commander's estimate of this effective range controls the distance at which the maneuver unit leader will first take evasive action to avoid a given weapon. When viewed from this perspective, it seems that a different interpretation should be applied to the numbers assigned to this common. Rather than list the estimated ranges of each weapon, one would be more correct to list the range within which a commander would take action to avoid a weapon of a given type. This would probably yield ranges greater than the maximum open fire range for a given weapon and more closely approximate the use of these numbers.

Unfortunately, a subjective evaluation seems to be the best source for these numbers. Care should be taken to insure that the subjective evaluation is performed by military personnel with experience in armor doctrine and tactics.

5. The size of the route selection matrix (1st value in RTKON), the frequency with which routes are computed (5th value in MANEUV), the size of environmental features, and the size of the maneuver units are all interrelated. This relationship should be considered when the input data are being prepared. Although the route selection matrix always contains the same number of points, the computer time required to select a route is not constant. As the matrix's size increases, the points become further apart. Hence the computer time required to determine the travel time to adjacent points increases.

6. KNTACL, the fifth value in common MANEUV, controls the maximum number of significant events that can transpire prior to the recomputation of the selected route. A significant event is defined as the detection of a previously unknown enemy or the kill of a known enemy. The route is recomputed when "enough" significant events have taken place to justify a route reselection. If the KNTACL value is small, then the route selection matrix should be reduced in size. If it is unlikely that the maneuver unit will traverse the entire route it has selected before the KNTACL value requires a route reselection, then selecting a long route is counterproductive. The additional computer time to select a long route will be used, but only a portion of the selected route will be used.

7. The size of the route selection matrix also interacts with the size of the environmental features. During the route selection event LOS is checked only to the points in the matrix itself. The LOS condition that exists at a point in the matrix is assumed to exist while traveling to that point. If the distance between points in the route selection matrix is small with respect to areas of cultural and forest features, the assumption is valid. However, if the distance between points is large with respect to areas of forest or towns, the assumption produces questionable results. Therefore, one should consider the size of environmental features when selecting a size for the route selection matrix.

8. The width of the maneuver unit also interacts with the route selection matrix. The model uses the fully deployed or half deployed formation width to calculate travel time from one point to another. (See discussion of travel time starting on page 5-44, Report AR 69-2A). Several travel paths are computed based on the width of a maneuver unit. The travel time used from one point to another is the longest travel time for any path. When the maneuver unit's width is small with respect to the width of the route selection matrix, the route selection procedure will function properly. However, when the maneuver unit width approaches or exceeds the size of the route selection matrix, then the different paths used to determine that travel time will essentially encompass the entire width of the route selection matrix regardless of the path being considered. This will cause the route selection process to lose its capability to discriminate among candidate routes.

9. One final point concerning route selection values: the range from the objective at which the maneuver unit stops its dynamic route selection and computes its assault path is contained in common RTKON (5th value). In order

to assume the appropriate assault formation this same value should be entered in common FORMAR (2nd value).

APPENDIX G

TARGET SELECTION

1. Each ground system selects its (ground) target with respect to seven different characteristics: range to target, target weapon type, whether the target was fired on in the previous event, whether the target is currently engaged by another friendly ground system, whether the target is inside the firer's sector of responsibility, whether the target fired in its last event, and whether the target fired at the selecting weapon in its last event. The last six factors are termed range adjustment factors (RAF). These RAF are given values subjectively to control their relative importance. The RAF are added to the actual range to adjust the priority of the target. The vehicle with the smallest $R+\Sigma RAF$ is chosen as the target. These RAF factors remain constant during the battle. This procedure of maintaining a constant value has its drawbacks. If the RAF are large enough to have an impact at long ranges, then they will be large enough to overwhelm the range value later in the battle. The variation in the relative importance of the range and the RAF was considered a shortcoming in the target prioritization scheme. Therefore, a new formula was devised that has the effect of varying the values of the RAF while maintaining the relative importance of the RAF to each other and to the range. The present formula is: adjusted range (priority) = $R+\Sigma RAF * \frac{R}{3000}$.

The scaling factor was set at 3,000 because that is the maximum range of any ground weapon.

2. The new formula has the advantage of modifying the value of the range adjustment factors with respect to the range. This allows the range and the adjustment factor to vary together in a reasonable fashion. At long ranges (close to 3,000 meters) the range adjustment factors have their maximum impact. At closer ranges, the range adjustment factors have a smaller impact and the actual range to the target becomes more important. The results from prioritization scheme were reviewed by senior officers at CACDA. When the results of the old and new prioritization schemes were compared, the new method was preferred.

APPENDIX H

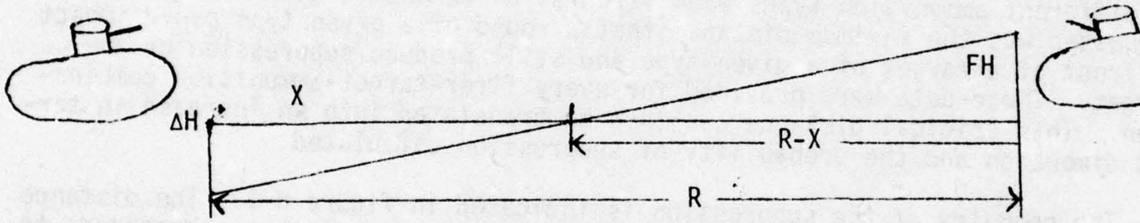
NEAR MISS SUPPRESSION

1. The play of near miss suppression by direct fire weapons was added to DYNTACS(X) during the HELLFIRE/CLGP COEAs. With this addition, the DYNTACS(X) model addressed the effects of suppression from casualty assessment and near misses from both direct and indirect fire.

2. For the purpose of this consideration, it was assumed that near misses to the sides or above the target would not cause suppression; only rounds impacting to the front of the target would cause suppression due to blast, fragmentation, and obscuration of vision. It was recognized that different round types would produce different effects, and different target types (tank, DRAGON team) would react differently to the same round. Therefore, data were requested from Ballistics Research Laboratory (BRL) on the suppressive effects of different ammunition types when fired at different targets. The data item requested was the maximum distance that a round of a given type could impact in front of a target of a given type and still produce suppression of the target. These data were provided for every firer-target-ammunition combination. This critical distance can then be translated into an increase in target dimension and the probability of suppression calculated.

3. The geometry of the suppression is indicated in figure H-1. The distance ΔH is the equivalent increase in the height of the target that corresponds to a round striking within the critical distance. First, the probability of hit on the normal target is calculated, then the probability of striking the enlarged target (normal target size increased by the near miss suppression ΔH) is calculated. During a firing event a random number is drawn and compared to the normal probability of hit. If the random number is larger than the normal probability of hit, then the same random number is compared to the probability of hit on the enlarged target. If the random number falls between the normal probability of hit on the actual target and the probability of hit on the enlarged target, then a near miss is declared and the target is suppressed. If the random number is larger than the probability of hit on the enlarged target a miss is declared and no action is taken.

4. The critical distances from BRL are stored in common SUPRES. Due to time limitations imposed on BRL, these values were based on blast effects only. In the future, more accurate data, which consider fragmentation and vision obscuration, should be generated.



FH = firer's height
R = range
X = critical distance for suppression
h = incremental target height based on X

Because of similar triangles: $\dfrac{X}{\Delta H} = \dfrac{R-X}{FH}$

Which yields: $\dfrac{X(FH)}{R-X} = \Delta H$

Geometry for Near Miss Suppression

FIGURE H-1

ANNEX I-I

PROBABILITY OF KILL TRANSFORMATION

1. The input for this program is in the form of card or card image tape. The output can be specified as tape or punch. This particular program is designed to read cards and produce punched output. There are several scenario dependent areas of the program presented:

a. The dimensions of HOLD depend on the number of target-firer-ammunition combinations allowed.

b. The calculation of indices will vary as function of the dimensions of HOLD.

c. The format in statement 100 is designed to produce the initial delete card used in the update of common PKTNK.

2. The program listing is attached as inclosure I-I-a.

APPENDIX I

PROBABILITY OF KILL DATA

1. When a hit is assessed in DYNTACS(X), five outcomes are possible: no damage, mobility only kill, firepower only kill, firepower and maneuver kill, and complete kill. (The last two categories are equivalent as far as the DYNTACS(X) model is concerned; both kill levels remove a weapon from further participation of any kind.) The probability of each occurrence is stored in either common PKTNK or common TPMKH. Common PKTNK is more detailed than TPMKH because it allows the probabilities of kill to vary as a function of target speed and aspect angle. Common PKTNK was originally designed to contain vulnerability data for tanks. However, it has since been expanded to include any element where the kill probabilities vary as a function of aspect angle (e.g., bunker with an aperture).

2. Army Materiel Systems Analysis Agency (AMSAA) is the source of all the vulnerability data used for the HELLFIRE COEA. The data provided by AMSAA are in a slightly different form from that required by DYNTACS(X). AMSAA provides the probability of maneuver kill, firepower kill, firepower or maneuver kill, and complete kill. Since these probabilities are not independent, they frequently total to a number greater than one. A trivial procedure is required to transform the data from the AMSAA format to the DYNTACS (X) format. A program to accomplish this transformation is included at annex I-I. When specifying the output format, one must be aware that some computers stop reading data in card image format when the first blank space is encountered. If this is the case, then it is necessary to insure that the zero printed by the machine will fill the format specified.

INCLOSURE I-I-a

TRANSFORMATION OF PROBABILITY OF KILL DATA

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```
//    EXEC FHG,REGION,G=200K
//F.SYSIN  DD  *
C     READ INPUT 4 PER CARD REPRESENTING KILLS(M,F,M OR F, K) TO CALC
C        NEW PROBABILITIES. INPUT IS BY KILL, RNG, ASPECT? SPEED,LTHTNK
C        OUTPUT IS BY RANGE,KILL,ASPECT,SPEED,LTHTNK
C
      DIMENSION HOLD(11,4,7,3,01),A(4)
      I=-1
    1 READ (5,2,END=3) A
C
    2 FORMAT(4F5.3)
    4 I=I+4
      I5=I/924+1
      I4=I/308+1
      IF(I4.GT.3)I4=I4-3*(I4/3)
       IF(I4.EQ.0)I4=3
      I3=I/44+1
      IF(I3.GT.7)I3=I3-7*(I3/7)
       IF(I3.EQ.0)I3=7
      I1=I/4+1
      IF(I1.GT.11)I1=I1-11*(I1/11)
      IF(I1.EQ.0)I1=11
C     COMPUTE PROB
C
      IF(I1 .GT. 3 .AND. I1/2 .EQ. (I1 + 1) / 2)GO TO 4
      HOLD(I1,1,I3,I4,I5)=1.0 - A(3)+ .00001
      HOLD(I1,2,I3,I4,I5)=A(3) - A(2)+.00001
      HOLD(I1,3,I3,I4,I5)=A(3) - A(1)+ .00001
      HOLD(I1,4,I3,I4,I5)=A(3)-HOLD(I1,2,I3,I4,I5)-HOLD(I1,3,I3,I4,I5)-A
     1 (4) + .00001
      IF(I1 .LT. 3)GO TO 4
      IF(I1 .EQ. 3)GO TO 1
      DO 6 J = 1,4
      HOLD(I1 - 1,J,I3,I4,I5) = (HOLD(I1,J,I3,I4,I5) + HOLD(I1 - 2,J,I3,
     .I4, I5))/2.
    6 CONTINUE
      GO TO 1
C     END OF DATA
    3 WRITE(6,5) HOLD
      WRITE(7,100)
  100 FORMAT("/.-116,3329",/,"PKTNK  COMMON  11*4*7*3*20")
      WRITE(7,5) HOLD
    5 FORMAT(10H       DEC,5X,F5.3,1H,,F5.3,1H,,F5.3,1H,,F5.3,1H,,F5.3,1
     AH,,F5.3,/10H       DEC,5X,F5.3,1H,,F5.3,1H,,F5.3,1H,,F5.3,1H,,F5.3
     B)
      STOP
      END
/*
//G.SYSIN  DD  *
```

APPENDIX J

IMAGINARY FO

1. In a Blue defensive scenario it is not unusual to portray a Blue company in the defense. The artillery support normally provided to a company is a fraction of the time of one battery of the direct support artillery battalion. Since there are no other Blue elements to call for fire, there is a danger of overstating the amount of artillery support available to the Blue company. In order to avoid this problem, the designers of DYNTACS(X) provided for an imaginary forward observer (FO) to represent the activities of the other FOs who would be requesting support from the same battery. In order to play the activities of the imaginary FO, the DYNTACS(X) user must specify the average time between calls for fire (common AMBDA) and the mean and standard deviation for the distribution of priorities and number of rounds (common UPRBRA, SIGPBR, URNBRA, SIGRBR). These values may be arbitrarily assigned by subjective evaluation. However, an alternative procedure is available if one run of DYNTACS(X) is made available for the purpose of determining these values.

2. A run of DYNTACS(X) is made with the values in AMBDA set to an arbitrarily selected large number. This will eliminate the imaginary FO from the run. The number of missions requested by the actual FO will be an accurate indication of the number of missions that would be requested by an FO who had undisputed access to a firing battery. If one assumes that the other FOs would be faced with a similar threat and similar terrain, then the information provided by the activity of the actual FO can be considered representative of the imaginery FOs. The distribution of priorities and rounds realized by the actual FO would be used for the imaginary FOs. The average time between missions for the actual FO would be divided by the number of FOs the imaginary FO is representing. (The imaginary FO would represent the activities of two FOs in a three-companies-forward defensive/delay posture.) By using the FO activity level in an actual DYNTACS(X) run, one can avoid making assumptions about expected FO activity in the DYNTACS(X) scenario that is being used.

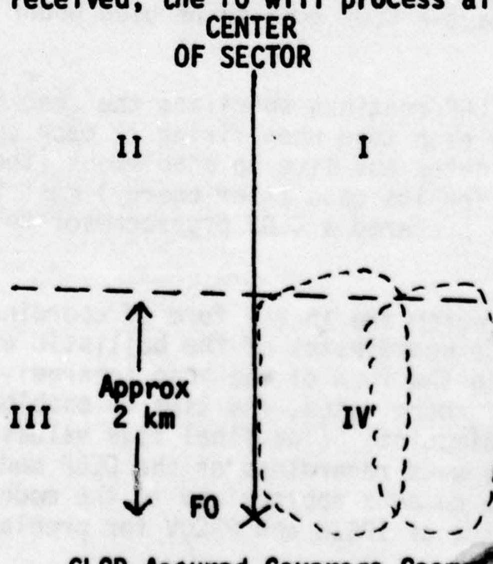
APPENDIX K

CANNON LAUNCHED GUIDED PROJECTILE

1. The Cannon Launched Guided Projectile (CLGP) routines in DYNTACS(X) were conceived, developed, and integrated into DYNTACS(X) at Rock Island Arsenal. The CLGP is a modified artillery round fired from a standard artillery piece and guided to its target by coded, reflected laser energy. The laser beam is focused on the target by the artillery FO party using a ground laser locator designator (GLLD). In the absence of a laser signal the projectile flies ballistically.

2. Three different modes of CLGP can be represented by the DYNTACS(X) routines: target of opportunity, assured coverage, and preplanned. The mode of CLGP used is strictly a function of the time the FO has had to prepare his fire plan. As soon as the FO is in position with the GLLD in operation, he can process target of opportunity missions for CLGP. Target of opportunity missions are condidered the least desirable because of the relatively long FDC processing time.

3. Once he is established in his position, the FO reports his location and the azimuth of the center of his sector of responsibility. The FDC will then divide the FO's sector of responsibility into four quadrants as shown in figure K-1. The FDC will then determine the number of CLGP rounds required to completely cover each quadrant. This is determined by computing the size of each footprint (the maximum maneuver capability of a CLGP round fired at a given range) and insuring that the combination of footprints completely covers a quadrant. (See quadrant IV in figure K-1. Here only two rounds are required to blanket the quadrant.) The deflection and quadrant elevation for each round are computed and sent to the battery. When all four quadrants have been processed, the FDC notifies the FO that assured coverage is available. (Until this notification is received, the FO will process all CLGP missions as targets



CLGP Assured Coverage Geom

FIGURE K-1

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APPENDIX K

CANNON LAUNCHED GUIDED PROJECTILE

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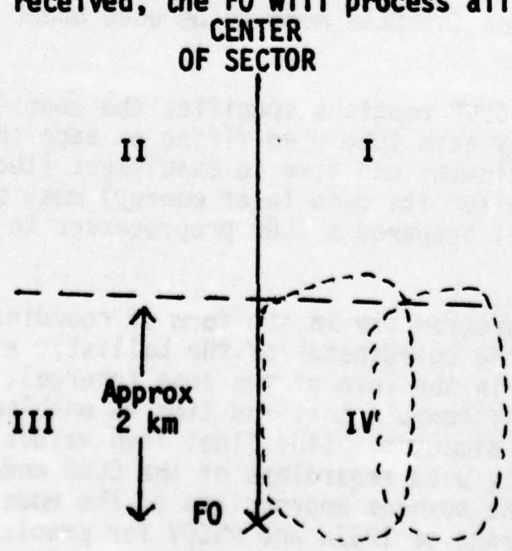

CLGP Assured Coverage Geometry

FIGURE K-1

of opportunity.) After receiving notification that assured coverage is available, the FO can initiate a CLGP mission by calling for a quadrant (e.g., FIRE MISSION, CLGP Quadrant III). When an assured coverage mission is executed, the battery simultaneously fires a round at each footprint in the quadrant. The FO is then guaranteed that any target in the quadrant will be within the footprint of at least one CLGP round. Because the firing data are precomputed, an assured coverage mission can be executed more quickly than a target of opportunity mission. However, since multiple CLGP rounds are fired for each target, assured coverage wastes the relatively scarce CLGP rounds.

4. While the FDC is preparing the firing data for the assured coverage mode, the FO party is selecting its preplanned concentrations. When this planning is completed, the FO will send his fire plan to the FDC. The FDC will then compute the basic firing data for each of the preplanned concentrations. When the FDC has completed its computation, the FO will be notified that preplanned fires are available. The FO will then process each CLGP mission as a preplanned concentration or shift from a known point (e.g., FIRE MISSION, CLGP, concentration 9006; FIRE MISSION, CLGP, from concentration 9007, add 200). The preplanned fire mode is considered the most desirable because it combines rapid response with a single round for each target.

5. Each mode allows the FO to request multiple volleys. The number of volleys to be fired versus target complex size is specified as input.

6. Since the FO progresses from a target of opportunity mode to the preplanned mode as time advances, specifying the mode of CLGP operation is essentially the same thing as specifying the length of time the FO has had to prepare himself before the battle began. Consequently, the CLGP mode to be used is tacitly embedded in the scenario. The scenario will usually specify the time available to prepare positions. By coordinating with the Field Artillery School, one can determine the CLGP mode to be used under the proposed time constraint.

7. The input data for CLGP routines specifies the zone (change) and quadrant elevation to be fired by each tube when firing at each concentration. The change in X and Y coordinates and time to enablement (the first time a CLGP round is able to search for its code laser energy) must be specified. Rock Island Arsenal personnel prepared a CLGP preprocessor to provide these input data.

8. The inputs to the program are in the form of coordinates of the firing pieces (XFB, YFB) and the coordinates of the ballistic aimpoints (XCONC, YCONC). The output is in the form of the zone (charge), quadrant elevation, range, change in X and Y coordinates, and time to enablement when a specific piece fires at a given aimpoint. (The final five values are not used as input.) This program is used regardless of the CLGP mode of fire used. The values are stored in the commons appropriate to the mode used (e.g., IASZN and ASCOV for assured coverage or IPSZN and PSCOV for preplanned mode). The program appears as annex K-I.

ANNEX K-I

CLGP PREPROCESSOR PROGRAM

```
      COMMON/TRAJD/TRAJD(6,5,8)
      COMMON/NTERMS/NTERMS(5,8)
      DIMENSION X(25),Y(25),XFB(6),YFB(6)
      INTEGER ZONE
      PRINT 107, ((ZONE,I,NTERMS(ZONE,I),(TRAJD(J,ZONE,I),J=1,6),
     1  I=1,8),ZONE=1,5)
  107  FORMAT(' ZONE    I TERMS COEFF'/(3I5,6E14.6))
      READ 101,XFB
      READ 101, YFB
  999 CONTINUE
      READ(5,100,END=996)N
  100 FORMAT(I10)
      READ 101,(X(I),I=1,N)
      READ 101,(Y(I),I=1,N)
  101 FORMAT(6F10.1)
      PRINT 103, XFB, YFB
  103 FORMAT(' XFB=',6F8.0/' YFB=',6F8.0/'0    XCONC    YCONC')
      PRINT 104,(X(I),Y(I),I=1,N)
  104 FORMAT(1X,2F8.0)
      DO 1 J=1,6
      PRINT 105,J
  105 FORMAT('0DATA FOR TUBE',I2,2X,50(1H*))
      PRINT 106
  106 FORMAT('0 I ZONE  QE   RANGE       XR       YR  TENAB  XENAB   YENAB
     1  THETA  VENAB  TBAL  XBAL')
      DO 1 I=1,N
      XR=X(I)-XFB(J)
      YR=Y(I)-YFB(J)
      R=SQRT(XR*XR +YR*YR)
      IZONE=IZONER(R)
      CALL BLNCH(R,IZONE,QE,T)
      ZONE=IZONE
      XE=EVALPY(QE,TRAJD(1,ZONE,2),NTERMS(ZONE,2))
      YE=EVALPY(QE,TRAJD(1,ZONE,3),NTERMS(ZONE,3))
      TE=EVALPY(QE,TRAJD(1,ZONE,5),NTERMS(ZONE,5))
      VE=EVALPY(QE,TRAJD(1,ZONE,4),NTERMS(ZONE,4))
      TR=EVALPY(QE,TRAJD(1,ZONE,6),NTERMS(ZONE,6))
      XB=EVALPY(QE,TRAJD(1,ZONE,7),NTERMS(ZONE,7))
      PRINT 102,I,ZONE,QE,R,XR,YR,T,XE,YE,TE,VE,TB,XB
  102 FORMAT(2I3,F7.2,3F8.1,F6.2,2F8.1,F6.1,F7.1,F6.2,F8.1)
      WRITE(7,997) QE,R,XR,YR,T
  997 FORMAT(7X,'DEC',4X,F11.4)
    1 CONTINUE
      PRINT 998
  998 FORMAT(1H1)
      GO TO 999
  996 CONTINUE
      STOP
      END
```

```
      SUBROUTINE BLNCH(RO,ZONE,QE,TERAB)
      INTEGER ZONE                                                   153
      COMMON/TRAJU/TRAJU(6,5,1)
      COMMON/NTERMS/NTERMS(5,1)
      COMMON/RCONST/RMIN,RMAX
      R=RO*1.0E-3                                                    154
      IF(R.LT.RMIN) GO TO 2
      IF(R.GT.RMAX)GO TO 8
    3 QE=EVALPY(R,TRAJU(1,ZONE,8),NTERMS(ZONE,8))
      QE=1.0/QE
      IF (QE.LT.11.0) GO TO 7                                        160
      IF (QE.GE.42.0) GO TO 1                                        161
    6 T=0.0                                                          162
      T=EVALPY(QE,TRAJU(1,ZONE,1),NTERMS(ZONE,1))
      TERAB=T                                                        165
      GO TO 90
    1 IF (ZONE.EQ.5) GO TO 8                                         167
      ZONE=ZONE+1                                                    168
      GO TO 3                                                        169
    7 IF (ZONE.EQ.1) GO TO 2                                         170
      ZONE=ZONE-1                                                    171
      GO TO 3                                                        172
    2 QE=11.0                                                        173
      GO TO 6                                                        175
    8 QE=45.0                                                        176
      GO TO 6                                                        178
   90 RETURN
      END                                                            179
```

```
0001            FUNCTION IZONER(R)
              C
              C**** THIS SUBROUTINE COMPUTES THE CORRECT ZONE FOR A GIVEN RANGE.
              C
0002            COMMON/ZRANG/ZRANG(1)
0003            ZRANG(1)=3402.903
0004            ZRANG(2)=5428.799
0005            ZRANG(3)=6820.891
0006            ZRANG(4)=7941.422
0007            ZRANG(5)=9853.520
0008            ZRANG(6)=15537.38
0009            DO 1 I=2,6
0010            IF (R.LE.ZRANG(I)) GO TO 2
0011          1 CONTINUE
0012            I=6
0013          2 IZONER=I-1
0014            RETURN
0015            END
```

```
      FUNCTION EVALPY(X,A,N)
      DIMENSION A(6)
      EVALPY=0.
      M=N+1
      DO 10 I=1,N
   10 EVALPY=A(M-I)+X*EVALPY
      RETURN
      END
```

FORTRAN IV G LEVEL 21 EVALPY DATE = 75212 08/53/13

```
      FUNCTION EVALPY(X,A,N)
      DIMENSION A(6)
      EVALPY=0.
      M=N+1
      DO 10 I=1,N
   10 EVALPY=A(M-I)+X*EVALPY
      RETURN
      END
```

ZONE	I	TERMS	COEFF					
1	1	3	-0.116609E 01	0.805712E 00	-0.190485E-02	0.0	0.0	0.0
1	2	4	-0.192932E 03	0.229095E 03	-0.117728E 01	-0.197211E-01	0.0	0.0
1	3	4	-0.865408E 01	0.278705E 01	0.121284E 01	-0.115330E-01	0.0	0.0
1	4	5	0.305391E 03	-0.258156E 01	-0.297675E-01	0.118365E-02	-0.899000E-05	0.0
1	5	3	0.143173E 01	-0.353329E 00	-0.840834E-02	0.0	0.0	0.0
1	6	3	-0.314063E 00	0.116284E 01	-0.514270E-02	0.0	0.0	0.0
1	7	6	0.192935E-01	0.332094E 00	-0.311080E-02	-0.177100E-04	-0.180000E-06	0.0
1	8	6	0.633325E 00	-0.454617E 00	0.157842E 00	-0.290826E-01	0.272500E-02	-0.102400E-03
2	1	3	-0.138793E 01	0.955701E 00	-0.219043E-02	0.0	0.0	0.0
2	2	4	-0.197521E 03	0.306653E 03	-0.201417E 01	-0.183944E-01	0.0	0.0
2	3	4	-0.740090E 01	0.681263E 01	0.132061E 01	-0.135161E-01	0.0	0.0
2	4	5	0.354682E 03	-0.706250E 01	0.197875E 00	-0.369482E-02	0.307808E-04	0.0
2	5	3	0.292667E 01	-0.571661E 00	0.679370E-02	0.0	0.0	0.0
2	6	5	0.842393E 00	0.130014E 01	-0.132333E-01	0.344460E-03	-0.408700E-05	0.0
2	7	6	0.383242E 00	0.402369E 00	-0.465708E-02	-0.256600E-04	-0.629000E-06	0.0
2	8	6	0.736898E 00	-0.423859E 00	0.115138E 00	-0.165238E-01	0.120698E-02	-0.354200E-04
3	1	4	0.901916E 00	0.872703E 00	0.455454E-02	-0.725240E-04	0.0	0.0
3	2	4	0.785795E 03	0.309123E 03	-0.797453E 00	-0.361923E-01	0.0	0.0
3	3	2	-0.283775E 03	0.495079E 02	0.0	0.0	0.0	0.0
3	4	5	0.405059E 03	-0.131859E 02	0.509367E 00	-0.100370E-01	0.786690E-04	0.0
3	5	4	0.375546E 00	-0.358516E 00	-0.201914E-01	0.173458E-03	0.0	0.0
3	6	3	0.116716E 01	0.136950E 01	-0.533328E-02	0.0	0.0	0.0
3	7	5	0.105816E 01	0.472511E 00	-0.656650E-02	0.541000E-04	-0.593900E-06	0.0
3	8	6	0.101763E 01	-0.499231E 00	0.111293E 00	-0.129645E-01	0.766710E-03	-0.182165E-04
4	1	3	-0.497746E-01	0.115570E 01	-0.257140E-02	0.0	0.0	0.0
4	2	4	0.841331E 03	0.411628E 03	-0.355938E 01	-0.989936E-02	0.0	0.0
4	3	2	-0.258335E 03	0.524775E 02	0.0	0.0	0.0	0.0
4	4	5	0.468677E 03	-0.224066E 02	0.100255E 01	-0.207908E-01	0.163871E-03	0.0
4	5	3	0.461040E 01	-0.100001E 01	-0.158900E-02	0.0	0.0	0.0
4	6	5	-0.184899E 01	0.225558E 01	-0.540699E-01	0.117987E-02	-0.100700E-04	0.0
4	7	5	0.156299E 01	0.544204E 00	-0.945350E-02	0.118800E-03	-0.115700E-05	0.0
4	8	6	0.127993E 01	-0.563095E 00	0.110307E 00	-0.112264E-01	-0.487123E-03	-0.120033E-04
5	1	5	0.189293E 00	0.148312E 01	-0.186588E-01	0.487560E-03	-0.487000E-05	0.0
5	2	5	0.151421E 04	0.567607E 03	-0.118830E 02	0.221709E 00	-0.227988E-02	0.0
5	3	3	-0.345232E 03	0.723645E 02	-0.336401E 00	0.0	0.0	0.0
5	4	5	0.514705E 03	-0.279244E 02	0.123489E 01	-0.239850E-01	0.175770E-03	0.0
5	5	4	0.290950E 01	-0.885225E 00	-0.141961E-01	0.194230E-03	0.0	0.0
5	6	3	0.442867E 01	0.155427E 01	-0.571434E-02	0.0	0.0	0.0
5	7	3	0.317983E 01	0.530064E 00	-0.567669E-02	0.0	0.0	0.0
5	8	6	0.200286E 01	-0.752597E 00	0.121624E 00	-0.100946E-01	0.423320E-03	-0.712864E-05

XFB= 1548. 1548. 1523. 1523. 1573. 1573.
YFB= 358. 308. 408. 258. 458. 208.

XCONC	YCONC
9847.	2254.
9400.	900.
9786.	481.
8437.	2309.
8540.	1407.
8374.	522.
7508.	2337.
7622.	1598.
7606.	1023.
7388.	365.
11052.	2023.
11169.	1312.
10992.	699.

DATA FOR TUBE 1 **

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	3	21.22	8512.8	8299.0	1896.0	20.78	6640.8	766.9	-14.7	274.7	27.83	8.5

2	3	18.65	7870.7	7852.0	542.0	18.29	6039.5	639.7	-12.2	280.7	24.86	7.9
3	3	20.10	8238.9	8238.0	123.0	19.69	6382.0	711.1	-13.6	277.2	26.53	8.2
4	3	16.10	7159.9	6889.0	1951.0	15.83	5405.[illegible]	513.5	-9.9	288.2	21.84	7.2
5	3	15.80	7070.3	6992.0	1049.0	15.54	5328.3	498.5	-9.6	289.2	21.47	7.1
6	3	15.00	6828.0	6826.0	164.0	14.78	5121.9	459.0	-9.0	292.0	20.51	6.8
7	2	18.26	6280.0	5960.0	1979.0	15.33	4617.7	474.9	-5.2	272.6	21.81	6.0
8	2	17.92	6199.3	6074.0	1240.0	15.04	4546.1	461.2	-5.1	273.6	21.46	5.9
9	2	17.50	6094.4	6058.0	665.0	14.67	4453.4	443.8	-5.0	274.8	21.00	5.8
10	2	16.50	5840.0	5840.0	7.0	13.79	4231.5	403.9	-4.7	277.7	19.94	5.6
11	3	26.35	9648.7	9504.0	1665.0	25.73	7715.3	1020.7	-19.9	265.6	33.55	9.7
12	3	26.45	9668.2	9621.0	954.0	25.82	7733.6	1025.5	-20.0	265.4	33.65	9.7
13	3	25.40	9450.2	9444.0	341.0	24.82	7529.4	973.6	-18.9	267.0	32.51	9.5

DATA FOR TUBE 2 **

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	3	21.27	8524.1	8299.0	1946.0	20.82	6651.1	769.1	-14.7	274.6	27.88	8.5
2	3	18.67	7874.3	7852.0	592.0	18.31	6042.9	640.4	-12.2	280.7	24.87	7.9
3	3	20.10	8239.8	8238.0	173.0	19.69	6382.5	711.2	-13.6	277.2	26.54	8.2
4	3	16.15	7173.7	6889.0	2001.0	15.88	5417.6	515.8	-10.0	288.0	21.89	7.2
5	3	15.83	7077.8	6992.0	1099.0	15.57	5334.8	499.8	-9.7	289.1	21.51	7.1
6	3	15.01	6829.4	6826.0	214.0	14.78	5123.1	459.2	-9.0	292.0	20.52	6.8
7	2	18.32	6295.9	5960.0	2029.0	15.39	4632.0	477.7	-5.3	272.4	21.88	6.0
8	2	17.97	6209.5	6074.0	1290.0	15.08	4555.0	462.9	-5.2	273.4	21.50	5.9
9	2	17.52	6100.0	6058.0	715.0	14.69	4458.3	444.7	-5.0	274.7	21.03	5.8
10	2	16.50	5840.3	5840.0	57.0	13.79	4231.8	403.9	-4.7	277.7	19.94	5.6
11	3	26.39	9657.5	9504.0	1715.0	25.77	7723.4	1022.8	-20.0	265.5	33.60	9.7
12	3	26.47	9673.2	9621.0	1004.0	25.85	7738.0	1026.6	-20.0	265.4	33.68	9.7
13	3	25.41	9452.1	9444.0	391.0	24.83	7531.3	974.1	-18.9	267.0	32.52	9.5

DATA FOR TUBE 3 **

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	3	21.28	8526.2	8324.0	1846.0	20.83	6653.5	769.6	-14.7	274.5	27.89	8.5
2	3	18.74	7892.4	7877.0	492.0	18.37	6059.5	643.8	-12.3	280.5	24.95	7.9
3	3	20.19	8263.3	8263.0	73.0	19.78	6404.8	716.0	-13.7	276.9	26.65	8.3
4	3	16.14	7170.6	6914.0	1901.0	15.87	5414.8	515.2	-9.9	288.1	21.88	7.2
5	3	15.86	7087.8	7017.0	999.0	15.60	5343.4	501.4	-9.7	289.0	21.55	7.1
6	3	15.08	6851.9	6851.0	114.0	14.85	5142.2	462.9	-9.0	291.7	20.61	6.8
7	2	18.29	6288.2	5985.0	1929.0	15.36	4625.0	476.3	-5.3	272.5	21.85	6.0
8	2	17.98	6214.0	6099.0	1190.0	15.09	4559.1	463.7	-5.2	273.4	21.52	5.9
9	2	17.58	6114.0	6083.0	615.0	14.73	4470.7	447.0	-5.0	274.5	21.09	5.8
10	2	16.60	5865.2	5865.0	-43.0	13.87	4253.2	407.7	-4.7	277.4	20.04	5.6
11	3	26.43	9664.9	9529.0	1615.0	25.81	7731.1	1024.8	-20.0	265.4	33.64	9.7
12	3	26.54	9688.3	9646.0	904.0	25.92	7752.0	1030.3	-20.1	265.3	33.76	9.7
13	3	25.51	9473.5	9469.0	291.0	24.92	7550.9	979.0	-19.0	266.9	32.63	9.5

DATA FOR TUBE 4 **

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	3	21.42	8560.0	8324.0	1996.0	20.97	6685.4	776.6	-14.9	274.2	28.05	8.6
2	3	18.78	7903.1	7877.0	642.0	18.41	6069.4	645.8	-12.3	280.4	25.00	7.9
3	3	20.20	8266.0	8263.0	223.0	19.79	6407.3	716.5	-13.7	276.9	26.66	8.3
4	3	16.28	7211.8	6914.0	2051.0	16.00	5450.7	522.2	-10.1	287.6	22.05	7.2
5	3	15.94	7110.4	7017.0	1149.0	15.67	5362.9	505.2	-9.8	288.7	21.64	7.1
6	3	15.09	6856.1	6851.0	264.0	14.86	5145.7	463.5	-9.0	291.6	20.62	6.8
7	2	18.49	6335.8	5985.0	2079.0	15.53	4667.7	484.6	-5.3	272.0	22.06	6.0
8	2	18.11	6244.5	6099.0	1340.0	15.20	4586.2	468.8	-5.2	273.0	21.65	5.9
9	2	17.65	6130.9	6083.0	765.0	14.79	4485.5	449.8	-5.0	274.4	21.16	5.8
10	2	16.60	5866.0	5865.0	107.0	13.87	4253.9	407.8	-4.7	277.4	20.04	5.6
11	3	26.56	9691.1	9529.0	1765.0	25.93	7754.7	1031.0	-20.1	265.3	33.77	9.7
12	3	26.62	9703.4	9646.0	1054.0	25.99	7766.3	1034.0	-20.2	265.2	33.84	9.7
13	3	25.53	9479.3	9469.0	441.0	24.95	7556.5	980.4	-19.1	266.8	32.66	9.5

DATA FOR TUBE 5 **

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	3	21.03	8466.7	8274.0	1796.0	20.59	6596.9	757.3	-14.5	275.1	27.61	8.5
2	3	18.53	7839.5	7827.0	442.0	18.18	6010.7	633.8	-12.1	281.0	24.72	7.8
3	3	19.99	8213.0	8213.0	23.0	19.59	6357.4	705.9	-13.5	277.4	26.41	8.2
4	3	15.93	7109.2	6864.0	1851.0	15.67	5361.8	505.0	-9.8	288.8	21.63	7.1
5	3	15.67	7031.3	6967.0	949.0	15.42	5294.9	492.1	-9.5	289.6	21.32	7.0
6	2	20.52	6801.3	6801.0	64.0	17.30	5088.4	571.8	-5.9	266.6	24.20	6.3
7	2	18.03	6225.3	5935.0	1879.0	15.13	4569.3	465.6	-5.2	273.3	21.57	5.9
8	2	17.75	6155.5	6049.0	1140.0	14.88	4507.3	453.9	-5.1	274.1	21.27	5.9
9	2	17.36	6059.4	6033.0	565.0	14.54	4422.7	438.1	-4.9	275.2	20.86	5.8
10	2	16.41	5815.7	5815.0	-93.0	13.70	4210.6	400.2	-4.6	278.0	19.84	5.6
11	3	26.15	9607.3	9479.0	1565.0	25.54	7676.4	1010.7	-19.7	265.9	33.33	9.6
12	3	26.28	9633.9	9596.0	854.0	25.66	7701.7	1017.2	-19.8	265.7	33.47	9.6
13	3	25.26	9422.1	9419.0	241.0	24.69	7503.0	967.0	-18.8	267.2	32.36	9.4

DATA FOR TUBE 6 ***

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	3	21.26	8523.2	8274.0	2046.0	20.82	6650.5	769.0	-14.7	274.6	27.88	8.5
2	3	18.60	7857.5	7827.0	692.0	18.25	6027.3	637.2	-12.2	280.8	24.80	7.9
3	3	20.01	8217.5	8213.0	273.0	19.61	6361.8	706.8	-13.5	277.4	26.43	8.2
4	3	16.17	7178.3	6864.0	2101.0	15.89	5421.7	516.6	-10.0	288.0	21.91	7.2
5	3	15.80	7069.4	6967.0	1199.0	15.54	5327.7	498.4	-9.6	289.2	21.47	7.1
6	2	20.55	6808.2	6801.0	314.0	17.33	5094.8	573.2	-6.0	266.5	24.24	6.4
7	2	18.36	6305.3	5935.0	2129.0	15.42	4640.3	479.3	-5.3	272.3	21.92	6.0
8	2	17.95	6206.6	6049.0	1390.0	15.07	4552.6	462.4	-5.1	273.5	21.49	5.9
9	2	17.47	6087.8	6033.0	815.0	14.64	4447.6	442.7	-5.0	274.8	20.98	5.8
10	2	16.41	5817.1	5815.0	157.0	13.71	4211.8	400.4	-4.6	278.0	19.84	5.6
11	3	26.36	9651.2	9479.0	1815.0	25.75	7718.1	1021.5	-19.9	265.5	33.57	9.7
12	3	26.40	9659.3	9596.0	1104.0	25.78	7724.9	1023.2	-20.0	265.5	33.60	9.7
13	3	25.31	9431.8	9419.0	491.0	24.73	7512.1	969.3	-18.8	267.2	32.41	9.4

XFB= 1548. 1548. 1523. 1523. 1573. 1573.
YFB= 358. 308. 408. 258. 458. 208.

XCONC	YCONC
4800.	4500.
4800.	3500.
4800.	2500.
4800.	1500.
4800.	500.
5800.	4500.
5800.	3500.
5800.	2500.
5800.	1500.
5800.	500.
6800.	4500.
6800.	3500.
6800.	2500.
6800.	1500.
6800.	500.
7800.	4500.
7800.	3500.
7800.	2500.
7800.	1075.
7800.	1925.

DATA FOR TUBE 1 ***

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	1	19.88	5266.1	3252.0	4142.0	14.10	3741.0	435.6	-8.9	250.2	20.77	5.
2	1	16.19	4521.9	3252.0	3142.0	11.38	3123.2	305.3	-6.5	260.2	17.16	4.
3	1	13.49	3894.1	3252.0	2142.0	9.36	2635.8	221.5	-4.9	267.7	14.44	3.
4	1	11.70	3446.7	3252.0	1142.0	8.00	2294.7	171.5	-3.9	272.8	12.59	3.
5	1	11.00	3255.1	3252.0	142.0	7.47	2158.4	153.4	-3.5	274.8	11.85	3.
6	2	16.87	5936.0	4252.0	4142.0	14.11	4314.7	418.6	-4.8	276.6	20.33	5.
7	1	20.00	5286.9	4252.0	3142.0	14.18	3759.7	439.8	-9.0	249.9	20.88	5.
8	1	17.30	4761.1	4252.0	2142.0	12.21	3316.7	343.0	-7.2	257.1	18.27	4.
9	1	15.65	4402.7	4252.0	1142.0	10.98	3028.6	287.8	-6.2	261.7	16.63	4.
10	1	15.00	4254.4	4252.0	142.0	10.49	2912.5	267.2	-5.8	263.5	15.97	4.
11	2	20.02	6688.8	5252.0	4142.0	16.86	4986.1	549.7	-5.8	267.9	23.67	6.
12	2	17.60	6120.1	5252.0	3142.0	14.76	4476.0	448.0	-5.0	274.5	21.11	5.
13	2	15.67	5672.0	5252.0	2142.0	13.22	4087.1	379.1	-4.4	279.6	19.25	5.
14	1	20.48	5374.7	5252.0	1142.0	14.53	3835.3	457.9	-9.3	248.6	21.34	5.
15	1	19.82	5253.9	5252.0	142.0	14.05	3731.3	433.1	-8.9	250.4	20.71	5.
16	3	17.29	7499.6	6252.0	4142.0	16.97	5704.0	572.0	-11.0	284.5	23.25	7.
17	3	15.56	6997.1	6252.0	3142.0	15.31	5265.7	486.4	-9.4	290.0	21.18	7.
18	2	19.66	6608.8	6252.0	2142.0	16.56	4913.5	534.4	-5.7	268.8	23.30	6.
19	2	18.31	6293.0	6252.0	717.0	15.38	4629.4	477.2	-5.3	272.5	21.87	6.
20	2	18.95	6445.4	6252.0	1567.0	15.94	4765.9	504.1	-5.5	270.7	22.55	6.

DATA FOR TUBE 2 ***

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	1	20.10	5305.5	3252.0	4192.0	14.26	3775.6	443.6	-9.1	249.6	20.98	5.
2	1	16.35	4556.8	3252.0	3192.0	11.49	3151.1	310.6	-6.6	259.8	17.32	4.
3	1	13.61	3921.8	3252.0	2192.0	9.45	2656.9	224.8	-4.9	267.4	14.56	3.
4	1	11.77	3463.6	3252.0	1192.0	8.05	2307.6	173.3	-3.9	272.6	12.66	3.
5	1	11.00	3257.7	3252.0	192.0	7.47	2158.4	153.4	-3.5	274.8	11.85	3.
6	2	17.01	5971.0	4252.0	4192.0	14.23	4345.2	424.0	-4.8	276.2	20.48	5.
7	1	20.16	5316.8	4252.0	3192.0	14.30	3785.3	445.9	-9.1	249.5	21.04	5.
8	1	17.41	4783.8	4252.0	2192.0	12.29	3335.4	346.8	-7.3	256.8	18.38	4.
9	1	15.71	4415.9	4252.0	1192.0	11.02	3039.1	289.7	-6.2	261.5	16.68	4.
10	1	15.01	4256.3	4252.0	192.0	10.50	2914.1	267.5	-5.8	263.5	15.98	4.
11	2	20.16	6719.8	5252.0	4192.0	16.98	5014.3	555.7	-5.8	267.5	23.82	6.

12	2	17.71	6145.5	5252.0	3192.0	14.85	4498.5	452.3	-5.1	274.2	21.25	5.8
13	2	15.94	5691.1	5252.0	2192.0	13.29	4103.4	381.9	-4.5	279.4	19.33	5.5
14	1	20.54	5385.6	5252.0	1192.0	14.58	3844.6	460.2	-9.4	248.5	21.40	5.3
15	1	19.83	5255.5	5252.0	192.0	14.06	3732.7	433.5	-8.9	250.3	20.72	5.2
16	3	17.38	7527.3	6252.0	4192.0	17.07	5728.6	576.9	-11.0	284.2	23.36	7.5
17	3	15.63	7019.7	6252.0	3192.0	15.38	5284.9	490.1	-9.5	289.8	21.27	7.0
18	2	19.73	6625.1	6252.0	2192.0	16.62	4928.3	537.5	-5.7	268.6	23.37	6.2
19	2	18.34	6298.9	6252.0	767.0	15.40	4634.6	478.2	-5.3	272.4	21.89	6.0
20	2	19.01	6457.7	6252.0	1617.0	15.99	4777.0	506.4	-5.5	270.6	22.61	6.1

DATA FOR TUBE 3 **

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	1	19.76	5242.4	3277.0	4092.0	14.01	3721.5	430.8	-8.8	250.5	20.65	5.2
2	1	16.11	4505.5	3277.0	3092.0	11.32	3110.1	302.8	-6.4	260.4	17.09	4.5
3	1	13.47	3887.8	3277.0	2092.0	9.34	2631.0	220.7	-4.9	267.8	14.42	3.9
4	1	11.73	3454.2	3277.0	1092.0	8.02	2300.4	172.3	-3.9	272.8	12.62	3.5
5	1	11.03	3278.3	3277.0	92.0	7.49	2164.9	154.2	-3.5	274.7	11.89	3.3
6	2	16.81	5919.2	4277.0	4092.0	14.06	4300.2	416.0	-4.8	276.8	20.27	5.7
7	1	19.95	5277.6	4277.0	3092.0	14.15	3751.7	437.9	-9.0	250.0	20.83	5.2
8	1	17.31	4761.2	4277.0	2092.0	12.21	3316.9	343.0	-7.2	257.1	18.27	4.7
9	1	15.70	4414.2	4277.0	1092.0	11.02	3037.7	289.5	-6.2	261.5	16.68	4.4
10	1	15.10	4278.0	4277.0	92.0	10.57	2930.9	270.4	-5.8	263.2	16.08	4.3
11	2	19.97	6677.7	5277.0	4092.0	16.82	4975.9	547.5	-5.8	268.0	23.62	6.3
12	2	17.59	6116.1	5277.0	3092.0	14.74	4472.5	447.4	-5.0	274.5	21.10	5.8
13	2	15.88	5676.5	5277.0	2092.0	13.24	4091.1	379.8	-4.4	279.6	19.27	5.5
14	1	20.55	5388.8	5277.0	1092.0	14.59	3847.4	460.9	-9.4	248.4	21.42	5.3
15	1	19.95	5277.8	5277.0	92.0	14.15	3751.8	438.0	-9.0	250.0	20.83	5.2
16	3	17.26	7493.0	6277.0	4092.0	16.95	5698.0	570.8	-10.9	284.6	23.22	7.5
17	3	15.56	6997.2	6277.0	3092.0	15.31	5265.7	486.4	-9.4	290.0	21.18	7.0
18	2	19.70	6616.4	6277.0	2092.0	16.59	4920.4	535.8	-5.7	268.7	23.33	6.2
19	2	18.39	6312.3	6277.0	667.0	15.45	4646.7	480.5	-5.3	272.3	21.95	6.0
20	2	19.01	6457.7	6277.0	1517.0	15.99	4777.1	506.4	-5.5	270.6	22.61	6.1

DATA FOR TUBE 4 **

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	1	20.40	5360.3	3277.0	4242.0	14.48	3822.9	454.9	-9.3	248.8	21.27	5.3
2	1	16.59	4609.7	3277.0	3242.0	11.68	3193.6	318.7	-6.7	259.1	17.56	4.6
3	1	13.81	3970.6	3277.0	2242.0	9.60	2694.1	230.7	-5.1	266.9	14.76	4.0
4	1	11.93	3504.5	3277.0	1242.0	8.17	2339.0	177.6	-4.0	272.2	12.83	3.5
5	1	11.06	3285.9	3277.0	242.0	7.51	2170.8	155.0	-3.5	274.7	11.92	3.3
6	2	17.22	6023.9	4277.0	4242.0	14.42	4391.5	432.4	-4.9	275.6	20.70	5.7
7	1	20.43	5366.9	4277.0	3242.0	14.50	3828.5	456.3	-9.3	248.7	21.30	5.3
8	1	17.63	4829.0	4277.0	2242.0	12.45	3372.7	354.4	-7.4	256.2	18.59	4.8
9	1	15.88	4453.7	4277.0	1242.0	11.15	3068.9	295.2	-6.3	261.1	16.85	4.4
10	1	15.13	4283.8	4277.0	242.0	10.59	2935.5	271.2	-5.8	263.1	16.10	4.3
11	2	20.38	6770.6	5277.0	4242.0	17.18	5060.3	565.7	-5.9	267.0	24.06	6.3
12	2	17.90	6193.3	5277.0	3242.0	15.02	4540.7	460.2	-5.1	273.6	21.43	5.9
13	2	16.10	5733.5	5277.0	2242.0	13.43	4139.8	388.0	-4.5	278.9	19.50	5.5
14	1	20.74	5421.2	5277.0	1242.0	14.72	3875.4	467.8	-9.5	247.9	21.59	5.4
15	1	19.97	5282.5	5277.0	242.0	14.17	3755.9	438.9	-9.0	249.9	20.86	5.2
16	3	17.56	7576.0	6277.0	4242.0	17.24	5772.2	585.6	-11.2	283.7	23.57	7.6
17	3	15.78	7064.8	6277.0	3242.0	15.52	5323.7	497.6	-9.6	289.3	21.45	7.1
18	2	19.91	6665.4	6277.0	2242.0	16.77	4964.7	545.1	-5.8	268.2	23.56	6.2
19	2	18.47	6329.9	6277.0	817.0	15.51	4662.4	483.6	-5.3	272.1	22.03	6.0
20	2	19.16	6494.6	6277.0	1667.0	16.12	4810.1	513.1	-5.5	270.2	22.77	6.1

DATA FOR TUBE 5 **

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	1	19.38	5172.2	3227.0	4042.0	13.73	3661.4	417.0	-8.6	251.5	20.29	5.1
2	1	15.79	4434.8	3227.0	3042.0	11.08	3053.9	292.5	-6.2	261.3	16.77	4.4
3	1	13.19	3818.8	3227.0	2042.0	9.13	2578.5	212.6	-4.7	268.6	14.13	3.8
4	1	11.48	3391.1	3227.0	1042.0	7.83	2251.9	165.7	-3.7	273.5	12.36	3.4
5	1	11.00	3227.3	3227.0	42.0	7.47	2158.4	153.4	-3.5	274.8	11.85	3.3

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
6	2	16.55	5648.5	4227.0	4042.0	13.61	4236.9	405.2	-4.7	277.6	19.97	5.6
7	1	19.57	5207.8	4227.0	3042.0	13.87	3691.8	424.0	-8.7	251.0	20.47	5.2
8	1	16.99	4694.4	4227.0	2042.0	11.97	3262.3	332.1	-7.0	258.0	17.95	4.7
9	1	15.43	4353.5	4227.0	1042.0	10.82	2990.0	280.9	-6.0	262.3	16.41	4.3
10	1	14.89	4227.2	4227.0	42.0	10.41	2891.4	263.5	-5.7	263.8	15.86	4.2
11	2	19.66	6607.5	5227.0	4042.0	16.55	4912.3	534.1	-5.7	268.8	23.29	6.2
12	2	17.31	6047.8	5227.0	3042.0	14.50	4412.3	436.2	-4.9	275.3	20.81	5.8
13	2	15.64	5611.7	5227.0	2042.0	13.02	4035.7	370.5	-4.4	280.3	19.01	5.4
14	1	20.23	5329.8	5227.0	1042.0	14.35	3796.6	448.6	-9.2	249.3	21.11	5.3
15	1	19.67	5227.2	5227.0	42.0	13.95	3708.3	427.8	-8.8	250.7	20.57	5.2
16	3	17.02	7423.8	6227.0	4042.0	16.71	5636.7	558.7	-10.7	285.3	22.93	7.4
17	3	15.34	6930.3	6227.0	3042.0	15.10	5208.7	475.5	-9.2	290.8	20.92	6.9
18	2	19.42	6553.3	6227.0	2042.0	16.35	4863.3	523.9	-5.6	269.5	23.04	6.2
19	2	18.16	6257.5	6227.0	617.0	15.25	4597.7	471.0	-5.2	272.9	21.71	5.9
20	2	18.75	6397.5	6227.0	1467.0	15.76	4722.8	495.5	-5.4	271.3	22.33	6.0

DATA FOR TUBE 6 **

I	ZONE	QE	RANGE	XR	YR	TENAB	XENAB	YENAB	THETA	VENAB	TBAL	XBAL
1	1	20.45	5369.8	3227.0	4292.0	14.51	3831.1	456.9	-9.3	248.7	21.32	5.3
2	1	16.59	4609.9	3227.0	3292.0	11.68	3193.7	318.7	-6.7	259.1	17.56	4.6
3	1	13.76	3958.1	3227.0	2292.0	9.56	2684.6	229.2	-5.0	267.0	14.71	3.9
4	1	11.82	3476.0	3227.0	1292.0	8.09	2317.2	174.6	-3.9	272.5	12.71	3.5
5	1	11.00	3240.2	3227.0	292.0	7.47	2158.4	153.4	-3.5	274.8	11.85	3.3
6	2	17.22	6024.0	4227.0	4292.0	14.42	4391.6	432.4	-4.9	275.6	20.71	5.7
7	1	20.38	5357.7	4227.0	3292.0	14.47	3820.6	454.4	-9.3	248.9	21.25	5.3
8	1	17.53	4808.4	4227.0	2292.0	12.38	3355.7	350.9	-7.3	256.5	18.49	4.8
9	1	15.73	4420.0	4227.0	1292.0	11.03	3042.3	290.3	-6.2	261.5	16.70	4.4
10	1	14.93	4237.1	4227.0	292.0	10.44	2899.1	264.9	-5.7	263.7	15.90	4.2
11	2	20.35	6763.3	5227.0	4292.0	17.15	5054.0	564.3	-5.9	267.0	24.02	6.3
12	2	17.84	6177.3	5227.0	3292.0	14.96	4526.6	457.5	-5.1	273.8	21.36	5.9
13	2	16.00	5707.4	5227.0	2292.0	13.34	4117.4	384.2	-4.5	279.2	19.40	5.5
14	1	20.53	5384.3	5227.0	1292.0	14.57	3843.5	460.0	-9.4	248.5	21.39	5.3
15	1	19.72	5235.1	5227.0	292.0	13.98	3715.3	429.4	-8.8	250.6	20.61	5.2
16	3	17.51	7562.9	6227.0	4292.0	17.19	5760.4	583.2	-11.2	283.8	23.52	7.6
17	3	15.71	7043.6	6227.0	3292.0	15.46	5305.5	494.1	-9.6	289.5	21.37	7.0
18	2	19.78	6635.4	6227.0	2292.0	16.66	4937.7	539.4	-5.7	268.5	23.42	6.2
19	2	18.29	6287.1	6227.0	867.0	15.36	4624.1	476.1	-5.3	272.5	21.84	6.0
20	2	19.01	6459.4	6227.0	1717.0	15.99	4778.5	506.7	-5.5	270.6	22.61	6.1

APPENDIX L

ARTILLERY FIRE PLAN

1. The artillery fire plan should be prepared by knowledgeable artillery personnel. The fire plan may include the artillery preparation, a counter-preparation, a rolling barrage, preplanned fires, or fire on targets of opportunity. It is important to be able to represent these kinds of artillery fire if a reasonable portrayal of the artillery fire plan is achieved.

2. The representation of the artillery preparation follows the DYNTACS(X) schedule of fires very closely. (See pp 10-50 to 10-52, Report AR 69-2B, The Tank Weapon System, The Systems Research Group, September 1969). The concentrations to be fired by each battery during the preparation are identified and linked together using common NXCONC. Then only the initial concentration for each battery needs to be listed in the schedule of fires. Since the load, lay, and fire time for each volley is the realization of a random variable, it is not possible to determine in advance how long the preparation will take to fire. Since the suppressive effects of the artillery are transitory, it is important to have the artillery preparation end at the proper time. A close approximation to having the preparation end at time zero (H-hour) can be attained by running the model with an arbitrarily selected start time for the preparation, noting the time that the preparation ends, and then adjusting the start time (common SCHTIM) so that the preparation ends at time zero. The same procedures are applicable to defender counter-preparation.

3. An important aspect of threat artillery is the rolling barrage of artillery preceding the attacking force. This can be adequately portrayed by the use of trigger areas. A series of target areas actuated by the attacking force and placed along the routes of advance will initiate a series of artillery fires directed at COP and then FEBA locations. Two sets of concentrations will probably be required. One set should cover suspected COP locations and should probably be fired until the attackers reach the vicinity of the COP. Then the second set, which would contain suspected FEBA locations, should be fired for the remainder of the battle.

4. The position and size of the trigger areas need to be selected with care. The size of the trigger area should be adjusted based on the size of the route selection matrix used. The trigger areas need to be large enough so that the manueuver unit designed to enter the trigger area will not be able to skirt the trigger area when the optimal route is selected. The distance between trigger areas should be based on the number of rounds fired for each trigger area and the rate of advance of the attackers. Since the goal is to produce a continuous volume of fire, the time between entries into successive trigger areas should correspond to the time required to process and fire the rounds required for each trigger area.

5. Experience has indicated that the walking fire pattern is inappropriate for the rolling barrage type of fire. A series of concentrations fired in sequence with a normal fire pattern can produce a heavier volume of fire over a larger area.

6. Trigger areas are useful for the defending force too. They can be placed along the route of withdrawal of the COP elements to provide covering fire for the COP withdrawal or to fire FASCAM rounds to close lanes in minefields after the COP has withdrawn.

7. The rules governing the use of trigger areas have changed slightly from those listed in the documentation. The maximum number of trigger areas is now 30. The Blue trigger areas still need to be listed first, but there is no arbitrary assignment of the trigger areas into Blue and Red trigger areas. The first Red trigger area is listed immediately after the last Blue area.

8. The DYTNACS(X) model has some difficulty in representing fire missions that are shifts from a known (preregistered) point. The only planned fires represented by DYNTACS(X) are the schedule of fires and trigger areas discussed previously. However, as the defensive force remains in position longer, more information is gathered by the artillery through survey, meteorological messages, registrations, and previous fire missions. This information allows the FDC to speed the processing of fire requests. DYNTACS(X) cannot dynamically represent this process. Therefore, the reaction times for processing "target of opportunity" missions should be modified, if appropriate, to reflect the greater efficiency of the FDC as time goes on. The adjustments considered appropriate will have to be subjectively determined by experienced military personnel based on the scenario within which the DYNTACS(X) battle is suppose to take place. The longer the defensive area is to be occupied prior to the initiation of the battle, the greater the adjustment to the "target of opportunity" reaction times.

9. By using all these capabilities of DYNTACS(X), a reasonable portrayal of nearly any fire plan can be achieved.

APPENDIX M

HELICOPTER OPERATIONS AREAS

1. Each helicopter is given a series of operations areas that define the general location of the helicopter at each stage of the battle. The operations areas are occupied in succession as each helicopter has to withdraw to maintain a prescribed distance from the advancing threat force. Three characteristics are used to describe each operations area: its location (CPLX, CPLY), size (AMAJOR, AMINOR), and the maximum altitude (OPALT) to which a helicopter can ascend in that operations area. The location and size of the operations areas are chosen in the same way that defensive positions are chosen for ground weapons. A TRADOC school or analyst selects initial positions for the helicopters. The line-of-sight (LOS) program in annex D-I is used to produce the line of sight at each position. The proposed tactics for the helicopters should specify the maximum altitude above near mask for the helicopters. This maximum height should be used as the height of the observing vehicle in the input data for the LOS program. The initial positions are adjusted as required, based on the results of the LOS program. As was the case in positioning ground weapons, the MAPLOT map and vegetation overlay will be useful tools for discarding obviously unsuitable positions. Once an acceptable set of positions has been selected, the actual height to be used in the DYNTACS(X) program can be determined.

2. The determination of near mask is a combination of subjective input and a computer program, which uses elevation and vegetation input. The analyst, using the computer map and vegetation overlay, selects a series of points, which may be the highest terrain/vegetation location in the vicinity of the operations areas. As a general rule, the center of the operations area and the four points on the perimeter of the operations area at the cardinal directions should be used. Points in "front" (toward the enemy) of the operations area are selected based on the terrain configuration and vegetation location in the near vicinity. Care should be taken to include all possible points that may block line-of-sight from the operations area. When these points have been selected, they are provided as input to the program in annex M-I. The output of the program is the height (above sea level) of the terrain and vegetation, if any, at that point. The point with the greatest height is declared to be the near mask point. The height at that point is used to define the height of the near mask for the operations area in question. The helicopter tactics specify the maximum height above near mask that a helicopter can attain. This value is added to the near mask height to determine the input value for common OPALT for the specified helicopter and operations area. When this procedure has been completed for all operations areas for all helicopters, all the values required for OPALT will have been determined.

3. If desired, a final LOS map may be produced for each operations area. The only change in the input data would be the height of the observing vehicle. The elevation at the center of the operations area is subtracted from the OPALT value for that operations area to produce the vehicle height used for the LOS program. In general, this number will be slightly larger than the original number. This final LOS map will represent the best line of sight available at the center of the operations area.

4. The proper size for an operations area can only be determined subjectively. When making this determination, one should consider that, in general, the larger the operations area the greater the difference between the minimum elevation of all points in the OPALT program and the maximum. This difference between the MAX and MIN represents the accuracy with which the altitude above near mask is controlled. If this difference gets large, it is possible that the helicopter will rise to an unacceptable height and become a victim of an air defense system.

ANNEX M-I

OPALT PROGRAM

1. OPALT is a special purpose utility program designed to obtain the elevation of selected points on the battlefield area, including the height of any trees at that point.

2. OPALT consists of the main program and two function subroutines (ELVATE) and TREES) extracted from the DYNTACS(X) model. The terrain features and the terrain elevation files are the same ones used in the DYNTACS production runs. Input to the program is on cards and consists of one point on the battlefield per card (F5.0, 5X, F5.0). The OPALT program is visusally depicted in figure M-I-1.

3. The program is attached as inclosure M-I-a.

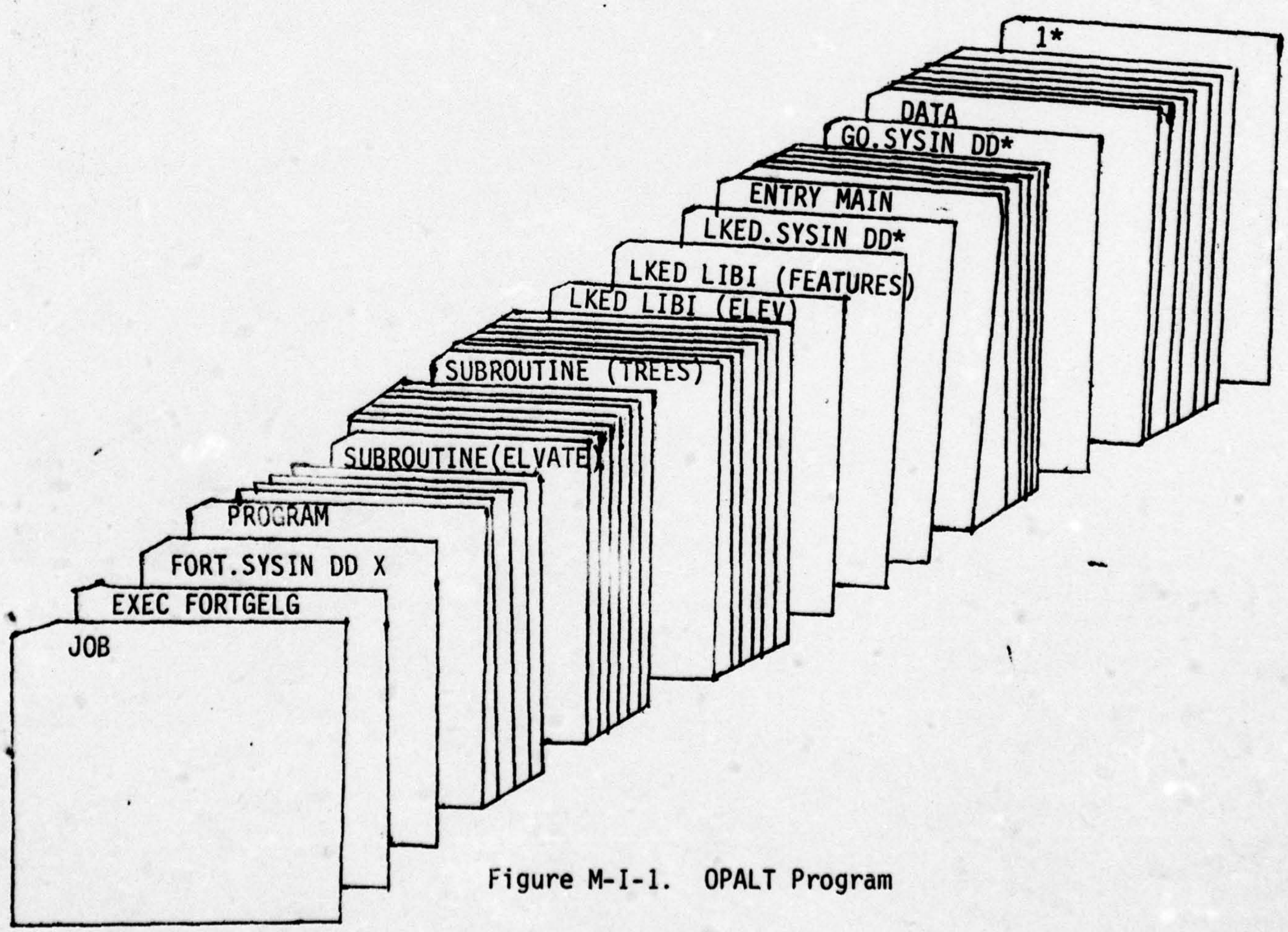

Figure M-I-1. OPALT Program

INCLOSURE M-I-a

OPALT PROGRAM

```
//CACDA21 JOB (XXXXXXXX,C,U,N),"GARRETT"
// EXEC FORTGCLG
//FORT.SYSIN DD *
      COMMON/DCON/H(60)
      DO 10 I=1,60
   10 H(I)=0.
      H(4)=3.
      H(10)=3.
      H(16)=3.
      H(22)=10.
      H(28)=10.
      H(34)=10.
      H(40)=10.
      H(46)=15.
      H(52)=5.
      H(58)=5.
    3 READ(5,1,END=99) X,Y
    1 FORMAT (F5.0,5X,F5.0)
      ELV=ELVATE(X,Y,0)+TREES(X,Y)
      WRITE (6,2) X,Y,ELV
    2 FORMAT (1X,2F8.0,F10.1)
      GO TO 3
   99 STOP
      END
      FUNCTION ELVATE(X,Y,IK)
      INTEGER*2 MAP
      COMMON /ELOCZ/ELOCZ(1)
      COMMON /LHICE/LHICE(1)
      COMMON/MAPCOM/E,NY,XMAX,YMAX,ZMAX,MAP(1)
      WX=X/E
      WY=Y/E
      IX=WX
      IY=WY
      RX=WX-FLOAT(IX)
      RY=WY-FLOAT(IY)
      IF (RX+RY.LE.1.0) GO TO 100
      RX=1.-RX
      RY=1.-RY
      IA=(IX+1)*NY+IY+2
      IB=IA-1
      IC=IA-NY
      GO TO 200
  100 CONTINUE
      IA=IX*NY+IY+1
      IB=IA+1
      IC=IA+NY
  200 CONTINUE
      A=MAP(IA)
      B=MAP(IB)
      C=MAP(IC)
      ELVATE=A+RX*(C-A)+RY*(B-A)
      IF(IK.EQ.0) RETURN
      IF(LHICE(IK).LE.0) RETURN
      IHCE=LHICE(IK)
      ELVATE=ELVATE+ELOCZ(IHCE)
      RETURN
      END
      FUNCTION TREES(X,Y)
      COMMON/DCON/DCON(6,1)
      COMMON/MINIRU/LIMITC,LIMITM,LIMITP
      COMMON/TD/TD(7,1)
      COMMON/TDDATA/NMBC,NMBP,NUMFC,NUMFP
      COMMON/TDP/TDP(7,1)
```

```
      COMMON/TDC/TDC(3,1)
      COMMON/TDFC/ITDFC(1)
      COMMON/TDFP/ITDFP(1)
      COMMON/FOREST/HTREE
      INTEGER*2 ITDFC,ITDFP
      INTEGER*2 TD
      HC=0.0
      JCODE=0
      IF (NUMFP.EQ.0) GO TO 20
      DO 10 J=1,NUMFP
      I=ITDFP(J)
      IF (X.LT.TDP(1,I))GO TO 20
      XINTCT=X-TDP(5,I)*Y
      IF (XINTCT.LT.TDP(6,I).OR.XINTCT.GT.TDP(7,I)) GO TO 10
      YINTCT=Y-TDP(2,I)*X
      IF (YINTCT.LT.TDP(3,I).OR.YINTCT.GT.TDP(4,I)) GO TO 10
      ISUB=TD(1,I)+1
      IF(DCON(4,ISUB).GT.HC) HC=DCON(4,ISUB)
      JCODE=1
   10 CONTINUE
   20 CONTINUE
      IF (NUMFC.EQ.0) GO TO 40
      I=ITDFC(J)
      K= I+LIMITP
      DO 30 J=1,NUMFC
      XT=X-TDC(1,I)
      IF(XT.GT.TDC(3,I)) GO TO 30
      IF(XT.LT.-TDC(3,I)) GO TO 40
      IF(XT**2+(Y-TDC(2,I))**2.LE.TDC(3,I)**2) GO TO 60
      GO TO 30
   60 ISUB=TD(1,K)+1
      IF(DCON(4,ISUB).GT.HC) HC=DCON(4,ISUB)
      JCODE=1
   30 CONTINUE
   40 IF(JCODE.EQ.1) GO TO 50
      TREES=0.
      RETURN
   50 TREES=HC
      RETURN
      END
/*
//LKED.LIB1 DD DSN=NAME.COEA.DECFULDA.BASEO,DISP=SHR
//LKED.LIB2 DD DSN=NAME.COEA.DECENT.FEATURES,DISP=SHR
//LKED.SYSIN DD *
      ENTRY MAIN
      INCLUDE LIB1
      INCLUDE LIB2
/*
//GO.SYSIN DD *
10996       1852
11096       1852
10896       1852
10996       1952
10996       1752
11020       1130
11120       1130
10920       1130
11020       1230
11020       1030
11110       1090
11210       1090
11010       1090
11110       1190
11110        990
10990        815
```

APPENDIX N

LIST OF DYNTACS(X) COMMONS BY SUBJECT

1. When initializing commons, it is convenient to know all the commons pertaining to one functional area (e.g., direct fire, artillery). Without having the commons grouped in this manner it would be difficult to approach the initialization of the data base in a systematic way.

2. When using the list at annex N-I, the following should be kept in mind:

a. If a common applies to more than one area, it may be listed in more than one category.

b. Commons dealing with artillery and missiles (i.e., those dimensioned by MWAIR) are listed in the Support Weapons category.

c. Commons affecting all fire request nets (i.e., dimensioned by NTFRNT) are listed in the Support Weapons category.

d. Beam Rider and EO missile commons are not presently used. They are included only for completeness.

e. Only commons requiring initialization are included in this list. All other commons must be checked to insure that they have appropriate dimensions.

ANNEX N-I

ORGANIZATION OF DYNTACS(X) COMMONS

1. Terrain and Environment

CONCOM	EMICR	TD
DCON	FOREST	TDC
DCOV	MAPCOM	TDDATA
DROUGH	MINC	TDFC
DSMOKE	MINP	TDFP
DTRAFF	MINTRU	TDP

2. Minefields

BREACH	DELAYT	PKPLOW
BRMODE	DMINES	SEQC
COUNTR	IMCOM	SEQP
DAMAGE	IVALDN	WIDTH
DBACK		

3. Organization

AMOV	ITORG	MANORG
IPORG	ITPAR	MANTYP
IPPAR	LIMNAT	NAVSEC
IPPOS	LMANU	NOUTFG
ISORG	LPOS	S
ISPAR	LSEC	SPTS
ISPOS	MANLDR	T

4. Communications

COMRAT	NFRMAX	NMOPN
MAXM	NMOBA	TRNET
MONLST	NMOCF	

5. Intelligence

BELOW	ETIM	INTEL
DETTSQ	FFLRD	NCAMO
EDIR		

PRECEDING PAGE BLANK-NOT FILMED

6. Crew Served Weapons

ICSWGP	LCSWEF	LCSWFN
LCREW		

7. Laser Designator Counter-Measures

IFOCCM	LUMDET	SPOOFO
LASDET	NITSIT	TIMENB

8. **Miscellaneous**

ATTACK	MISLE	SIDE
GRAV	NTELE	TGTDIM
IQUAD	NUMBER	TKLTH
IRANDX	PI	TKWTH
MAINPR	SEQPAR	TNEUT

9. Ground Mobility

ENGINE	LMOBT	MOBILE

10. Route Selection

DIFMF	ESMP	RTKON
DTIM	ET	SCAP
ESM	EW	TMEKON

11. Movement Controller

a. Basic

BEHIND	MINDEC	NPTS
DIRMU	MINTBR	RMVFR
FSPEED	MISION	XAXIS
KNTTAC	MOVPAR	XDP
LDPC	MUOBJ	YAXIS
MANEUV	NAXIS	YDP

b. Combat Outpost

AMOV	DELTIM	OUTPST
BREAK	FTMDEL	

12. Formations

ELOCX	FORMSX	FORMYS
ELOCY	FORMSY	IFNA
FORMAR	FORMXS	

13. Phase Lines

KADV	SPHAS	XPHAS
NPHAS	WPHAS	YPHAS
SPDPHS		

14. Direct Fire Weapons

AMMOCH	LWCOD	TARASP
EFELC	LWSYS	TARSPD
EMAX	MAXWEP	TMISF
EMIN	NOFLG	TMNEUT
ENGMET	PKOV	TMPRD
FIRKON	PKTNK	TPMKH
FMHITP	PMISF	TSDXM
HITP	PNPTBS	TSDYM
HITPRB	RPRIOR	TSDXMS
HPRNG	RPSIGX	TSDYMS
IHTPRB	RPSIGY	ULD
IPRAMO	SIGLD	ULY
IPRJCT	SIGLY	ULYN
KRC	SIGLYN	ULYNS
LAMMO	SUPRES	ULYS
LDFR	SYSCOD	VEHSPD
LTHTNK		

15. Target Selection

RAAS	RATF	RATT
RACT	RATFCE	SEGANG
RATE		

16. Fire Control Tactics

DKR	FIRCOM	FIRSPD

17. Air Defense

a. Basic

ABSCSA	MADRES	SPDCOD
ADPOD	MISCOD	STRICT
ADRATE	NLETH	STRNOT
ADSRG	NVC	TEVENT
AVA	OBSN	TREACT
BLRAD	PS	TTRACK
DALLOW	REFFEC	UREACT
FMOKIL	RMVFRA	UTRACK
FRACFR	SKY	VELIN
IADCE	SLEWAL	XPOD
IADPM	SLEWEL	YPOD

b. Launch Performance Envelope

AELIP	DXCYL	PHI
ALPHA	DYCYL	PSI
BELIP	NCONE	RADCYL
DELIP	NCYL	

c. Gun

ASDRG	PRJGUN	VAFRAZ
ATMDEN	TFBURI	VAFRZN
BETA	TFIRAD	VASRAZ
DELINC	VABGAZ	VASRZN
DT	VABGZN	

d. Missile

AB	CAB	TCAD
AC	CAC	THB
ALFAB	CAS	THS
ALFAC	CDIB	TS
ALFAS	CDIC	WB
ALMAX	CDIS	WC
AS	MACHPL	WS
B		

e. Target Selection

ADJASP	ADJFND	ADJWPN
ADJFIR	ADJTAR	ANGELM

f. Radar

AMBDAT	ITRRDR	RADTD
BANDWD	LOSF	SIGMD
GAINRC	NOIFIG	STONR
GAINTR	POWTR	TMAXCV

18. Support Fire

CLOSE	ITNMV	SIGADJ
DDFR	ITNRF	SIGCOM
DURFB	ITTFIR	SIGCOR
DURSTL	ITWSC	SIGONP
ENDMIS	JARMOR	SIGPLT
EVTIM	KILCRI	SIGSEN
FRN1	MNTHRS	SPCRIT
FRN2	MNTRIG	STRMIS
FRN3	NCRIT	UADJ
FRN4	NFRMAX	UCOM
FSCTIM	NHPB	UCOREC
GOEXAM	NRNDCN	UONP
ITC	REJTIM	UPLT
ITDIF	RMAXFO	URESPN
ITDIST	RMDES	USEN
ITDIT	RMINFO	WAITAD
ITDUR	RSAME	WAITFO
ITF	SFDIS	WAITMX
ITFFO		

19. Artillery

a. Basic

ADIMIS	LFUNC	SIGFFE
AFODUZ	LHVIS	SIGRAN
ANEUT	LNUM	TIMBE
ARTMIX	MINCHK	TNEUTM
ARTMIY	MSPCRN	UAL
BDIMIS	MSPPIR	UFFE
BNEUT	NFOCRT	URSTIM
CADJ	NFOMAX	VELCTY
CF	NKPAT	VULRAD
COMP	NOBVH	WPAT
DELD	NTOPFG	XFAC
DELR	ONDIST	XFB
DISTMV	ORESPN	XLOC
DURON	PKART	YFAC
FOCOM	RCRIT	YFB
INART	SIGAL	YLOC
LFBREQ	SIGDEF	

b. Fire Plan

INTRIG	MPRTRG	SCHTIM
ISCHPR	MSCH	SLSTIM
ITRIG	NCONC	XCONC
KPATRN	NSCH	XTRIG
MCONC	NSCHCN	YCONC
MFRNTG	NXCONC	YTRIG
MISCHN	RTRIG	

c. FO Bravo

AMBDA	SIGPBR	UPRBRA
DURC	SIGRBR	URNBRA

d. Counter-battery

AICTIM	KPATCB	SIGDIC
CBERR	LCBFIR	SIGICP
CBFTME	NRDDET	SIGRIC
CBNEUT	NRDFIR	STNEUT
DISCBB	NRDVAR	TAU
DISCBM	NRNVIS	UICPLT
DURAIC	PCONF	VARACT
HPRVIS	PCTDET	VARAIC
IHPRCB	PRBDET	XAIC
IPRAIC	RDNEUT	XFDC
IPRBAT	RDTIME	YAIC
IPRCBS	RECON	YFDC
IPRUNT		

e. Counter-battery

CLGP	IPSZN	RICLGP
AIMPX	NTERMS	RNEWGY
AIMPY	NCLGPF	RNGLS
ASCOV	NCLTOP	RPCLGP
AXIS	NFRORD	RRCLGP
CLGP	NFRTUB	TIMCLG
DETPX	NFRVOL	TIMNXT
DETPY	NPRE	TIMVOL
FBSEQ	NRPCLG	XCENTR
IASCOV	PSCOV	YCENTR
IASZN	RESTIM	ZPRED
IBTAMO		

20. Helicopter

a. Firing

ATDIR	IMIST	RDFMAX
ATLIM	JAMOAV	RDFMIN
BRAFM	KAMMAX	RGPTS
BRAFS	KAMOAV	RLNMAX
BRAIR	KAMPRD	RM
CALLOW	LNSET	RNGLS
CORR	MIDATA	SCANNS
DDPTS	MISHIT	SRPTS
DESAIR	MNSORG	TDUD
EFADTM	MSLPOS	TF
ERDY	NLNMAX	TLOAD
ERDYY	NM	TMISBR
ERDZ	NMISUN	TYPMIS
ERDZZ	NMLIM	VM
FLDTME	NRL	WT
IDYNOP	NRNDAT	XXAXIS
IFMC	PHNG	ZEEKER
IFRND	PNG	ZM
IHDFMC	RCOEF	ZMD

b. FO

NCLGPF	NFOMAX	NFUCRT
NFLCRT	NFMMAX	NOBVH

c. Vulnerability

DXOFF	LETHAV	VUNARP
DYOFF	NVUN	VUNARS
DZOFF	TCRIT	VUNX
INCMAX	TRET	VUNY
KILFIR	VUNARF	VUNZ

d. Formation

ELOCZ	FORMZS	ISFNA
FORMSZ	IHFNA	

e. Mobility

AIRIN	COPTER	RFUEL
CFUEL	MD	WFUEL
COMINT		

f. Movement Controller

DEFFCN	IUNACT	NTOBAL
DELAY	KMANU	NUMWPT
EVHTIM	LHICE	RADMA
HALTDS	MANHEL	REACT
HALTDU	MCLASS	RETFCN
HSPEED	NREQR	TIMARR
IPHASE		

g. Target Selection

ANGLIM	ARFCW6	MNUSR
ARFCW1	ARFCW7	RADINC
ARFCW2	ARFCW8	RADMAX
ARFCW3	ARFCW9	RADSEL
ARFCW4	CKANG	SRCONX
ARFCW5	ITYPA	SRCONY

h. Route Selection

AVENT	RTKONH	SSR
CMPT	RTSIZE	TBFR
DSVENT	SCAPH	TBL
DUVENT	SCLSON	TBSR
ESMH	SDL	TIMSR
RFOMAX	SFR	TURNON
RSTAS	SIGVNT	XLSTAS
RSTAU	SPEEDS	XLSTAU

i. Operation Areas

AMAJOR	CPLX	OPALT
AMINOR	CPLY	TILT
ATWPTS		

21. Indirect Missile

DTPTS	SDL	TMEINC
IFOMI	SFR	TYPMIS
INPRIR	SSR	VM
MSLPOS	TBFR	WT
NM	TBL	ZEEKFR
NMISUN	TBSR	ZM
NOBVH	TLOAD	ZMD
PNG		

22. Indirect Electro-optical

DETTV TVMIS

23. Beam Rider

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APPENDIX O

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HELLFIRE
Data Base
Combat Simulation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The DYNTACS(X) model is difficult to use properly. Its size (1.25 to 1.5 megabytes) and complexity (over 300 subroutines) are the main contributors to this situation. A thorough knowledge of the entire program, data base, and the interaction of these two components is required for a professional application of DYNTACS(X). One of the most demanding aspects of the operation of DYNTACS(X) is the preparation of the data base. An improperly prepared data base will impair the creditability of any results produced by the DYNTACS(X) model. Although the documentation prepared by Ohio State University is generally

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20. Sufficient for the purpose of determining data requirements, it does not always provide a method for producing the required data. This report includes several computer programs and data preprocessor programs, which are valuable in producing required data.

The DYNTACS(X) data base contains a large amount of subjective inputs. In some cases the subjective inputs are required because an empirical data base is not available (e.g., suppression). In other cases the subjective inputs are required to play tactical decision rules and tactics. Experience can be a valuable aid in the preparation of subjective input data. This report is an attempt to codify the experience achieved during the preparation of the HELLFIRE COEA data base.